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Research on Organizational Change in a National Network of Informal Science Education Institutions

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2017

ACKNOWLEDGMENTS

Without the help of many people, this research study would not have been possible.

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EXECUTIVE SUMMARY

Study overview

This study researched whether and how affiliation with the Nanoscale Informal Science Education Network (NISE Net) led to change in informal science education organizations' (ISEs) practices. The NISE Net provided an opportunity to look at how participation in a large but loosely-structured network of museums, science centers, educators, and scientists can influence museums to experience organizational change and adopt new practices.

By conducting qualitative case studies of a few selected partners, this research aimed to understand the conditions that facilitate or impede the influence of NISE Net-related practices within its network of partner organizations. Site visits to six highly involved NISE Net museums, separated by 18-20 months, allowed us to see changes that had a short-lived lifespan as well as those that looked as if they would be sustained over a longer period of time. By collecting data through a variety of methods—including interviews with staff members, volunteers, and scientist partners as well as onsite observations of meetings and programs—this study gained a rich sense of how each site functioned as a community, how each received, interpreted, and used information from NISE Net, and how this work changed over time.

The conceptual framework guiding this research was based on the notion of communities of practice, developed by Etienne Wenger (1998a; Lave & Wenger, 1991). We considered NISE Net and each of the participating museums to be a distinct community of practice because each had its own set of goals that the entire staff was working towards (i.e. joint enterprise), similar practices and tasks (i.e. mutual engagement), and a common pool of resources (i.e. shared repertoire). This study also considered how information from the Network flowed to and within the museums and whether there was alignment of goals between the six museums and NISE Net. This framing was important for understanding the changes that were occurring.

Findings

Overall, findings indicated that taking part in a network impacted the practices of the six organizations studied. Specifically, by participating in the NISE Network the museums made changes to their public nano offerings, to their practices unrelated to nano content, and to their partnerships with local scientists. While these changes were not all necessarily long-lasting, they show that participating in a network can affect an organization's work in a variety of ways.

Before joining NISE Net, most of the organizations in this study had no nano-related offerings. With the help of the Network's resources, all of the museums added new or additional nano exhibits and activities. The data indicate that nano exhibits often reflected a long-term change in the organization's practices. Not only were they typically on display for extensive periods, but they were expected to be on view for several years, and were generally not vulnerable to programmatic barriers such as staff members' schedules. This was the case for NISE Net's *Nano* exhibition which also had few barriers to public engagement and allowed museums to meet their organizational goals. Besides adding nano-related exhibits, the six

museums involved in the Network increased their nano programming. The NanoDays kit materials supplied by NISE Net were particularly useful in this regard. The NanoDays kits aligned with many of the museums' existing hands-on activities, adapted easily, and required little staff training. Yet nano programs were susceptible to shifting museum goals and to changing exhibits, vulnerable to staff transitions or busy workloads, as well as to additional factors that can typically affect museum programming.

While NISE Net also encouraged museums to adopt practices that were not specifically related to nano, findings suggest long-lasting change in these areas was less likely. Incorporating ideas about the societal costs and benefits of nano into programs and exhibits lost momentum due to factors such as the departure of key staff members who were strong advocates, a reluctance to try new things, and a mismatch with the school curriculum. The long-term use by staff members of new engagement techniques was hindered when staff lacked sufficient time to regularly continue this work. The inclusion of bilingual practices or evaluation was often affected by institutional priorities and by staff members' lack of familiarity with these practices. One organization, however, provided an example of how the practice of universal design can spread from NISE Net to many employees and become integrated into a museum's work if certain conditions are in place.

Collaboration between scientists and museum professionals was another practice encouraged by NISE Net and again an area in which we observed change. Before joining NISE Net, only one museum had nano-related partnerships with local scientists; after NISE Net involvement, this number rose to three of the six institutions. For these collaborations to take place, an alignment of museum and partner goals, from which both parties benefited, was critical. Additionally, NanoDays acted as a catalyst, and the annual nature of the event enabled partners to stay in touch. Nonetheless, staff turnover and communication difficulties sometimes hindered the lasting nature of the relationships.

Conclusions and implications

Overall analysis indicates that when there was alignment of goals between the Network and museums and an awareness of NISE Net products and practices among many staff, organizational change took place. The communities of practice framework helps explain how this change occurred because NISE Net, in essence, impacted the museums' practices and tasks (i.e. mutual engagement) and common resources (i.e. shared repertoires). When museum staff turned to nano or NISE Net products and practices as a way to carry out their own goals (i.e. joint enterprise), our study shows that being in the Network affected their community of practice on a larger scale. Ideas spread through museums due to the use of Network products (i.e. boundary objects) or from the people who had directly participated in NISE Net professional development opportunities (i.e. brokers). Change was often seen when museums took these new practices or products and formalized them into the work of the larger organization (i.e. process of reification). Opportunities for working together and exchanging new ideas helped integrate new ways of doing work into the community (i.e. process of participation).

When there was misalignment between the goals of NISE Net and the museums or when there were barriers to information flow within the organizations or between the partners and

NISE Net, it was unlikely to see staff at the museums discuss these new areas of work, integrate these ideas into their formalized practices or resources, or connect them to their underlying goals. However, this research found that when NISE Net was unable to affect long-lasting change, this was often due to the museums' contextual factors which were beyond NISE Net's control, for example, competing priorities, lack of time, and staff transitions.

Other networks may want to take into account similar strategies for influencing ISE organizations, such as exhibit resources and kit materials, yet this research recognizes that additional and new ways to influence museum practices can and should be explored.

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ORGANIZATION OF THIS REPORT

This report consists of four parts organized into nine chapters. Below is a brief description of the structure and contents of the document.

Part A of this report provides an introduction to the study, its methods, and research sites. It provides a broad overview of our study and contains useful background information that will be referred to throughout the report. In Chapter 1, we describe the research aims and communities of practice conceptual framework that guided our approach. In Chapter 2, we lay out the qualitative methodology we used in our multi-year data collection and analysis and how this approach allowed us to uncover patterns about the factors that promoted and hindered organizational change. Chapter 3 contains additional background information for understanding our work and findings, including definitions of terms used throughout the report—about, for instance, NISE Net's structure and products. It also contains introductions to the six research sites and a description of the Network Core Partners and their aims. This chapter begins to describe the context, the opportunities, and constraints among the organizations which were exposed to new ways of doing things and, perhaps, began to change their practices or adopt new ones.

Part B examines two essential conditions related to organizational change that emerged from our analysis: shared goals and the spread and application of new information into practice. For NISE Net to promote change in its partner museums, it was critical, that by participating in the Network, museums were able to accomplish their own goals as they simultaneously helped NISE Net achieve its aims. Whereas shared goals provided the motivation for staff members at partner museums to participate in NISE Net activities, organizational change necessitated that the information learned in these activities spread beyond the few individual staff members who were highly involved in NISE Net. In Chapter 4, we provide examples of the alignment or misalignment of goals, and, in Chapter 5, we explore the conditions that facilitated or hindered how information was shared from NISE Net and within individual study sites. Shared goals and the flow of information are key framing concepts for understanding the types of change reported in Part C.

Part C presents findings concerning the types of changes that occurred at our sites as a result of participating in NISE Net. We examined three primary areas of change: changes in partner museums' public offerings, such as programs and exhibits (Chapter 6); changes in the museums' practices unrelated to nano content (Chapter 7); and changes in museums' partnerships with local scientists (Chapter 8). In addition to descriptions of the organizational changes that we found, in these chapters we examine factors that facilitated and hindered change and influenced the widespread and long-lasting nature of change, referring to goal alignment, information spread, and other contextual features mentioned earlier in the report.

Part D offers a summary of the project and our findings, and a concluding discussion (Chapter 9). By summarizing the conditions that facilitated organizational change and the barriers that hindered it, this chapter makes connections for future research and other projects.

PART A: INTRODUCTION TO
RESEARCH STUDY, METHODS, AND SITES

Part A of this report provides an introduction to the study, its methods, and research sites. It provides a broad overview of our study and contains useful background information that will be referred to throughout the report. In Chapter 1, we describe the research aims and communities of practice conceptual framework that guided our approach. In Chapter 2, we lay out the qualitative methodology we used in our multi-year data collection and analysis and how this approach allowed us to uncover patterns about the factors that promoted and hindered organizational change. Chapter 3 contains additional background information for understanding our work and findings, including definitions of terms used throughout the report—about, for instance, NISE Net's structure and products. It also contains introductions to the six research sites and a description of the Network Core Partners and their aims. This chapter begins to describe the context, the opportunities, and constraints among the organizations which were exposed to new ways of doing things and, perhaps, began to change their practices or adopt new ones.

CHAPTER 1. STUDY OVERVIEW AND GUIDING FRAMEWORK

A.1.1 RESEARCH AIMS

More and more museums are currently taking on new missions and roles dedicated to fulfilling broad social and educational goals (Hirzy, 2008; Roberts, 1997). Informal science education organizations (ISEs), in particular, are challenged to adopt innovative practices that will introduce the public to current and complex science content and engage them in considerations of socio-scientific issues (Kollmann, Reich, Bell, & Goss, 2013). Additional challenges for ISEs include the need to broaden their audiences to include traditionally underrepresented groups and to employ techniques that promote inquiry and life-long learning (National Research Council, 2009). Accomplishing these goals will require many museums to change their practices. Yet, as Reich (2014) pointed out, we have lacked "a strong description of the context and practices that contribute to or detract from change" in museums (p. 7).

The Nanoscale Informal Science Education Network (NISE Net) provided an opportunity to look at one approach for promoting organizational change among ISEs—how participation in NISE Net, a large but loosely-structured network of museums, science centers, educators, and scientist partners, could lead museums to change and adopt new practices. NISE Net created "a national community of researchers and informal science educators dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology" (NISE Net, 2014c, para. 1). The team conducting this study consisted of members from the Museum of Science, Boston, and the Science Museum of Minnesota who were part of the NISE Net's larger Research workgroup. For this project, we investigated how partner museums received and acted on the ideas, techniques, and products that the Network made available to them; specifically, we researched the processes and conditions that facilitated or impeded the adoption and retention of NISE Net-related practices within its network of partner museums. As a result of these aims, we sought to answer the following research questions:

1. What does organizational change look like among science museums and centers as a result of their participation in a national network whose aim is to increase these organizations' capacity to foster public awareness, engagement, and understanding of nanoscale science, engineering, and technology (nano)?

2. What are the factors that facilitate or hinder organizational change for these organizations?

Organizational change can be characterized in many ways and entails numerous sub-processes. Kezar (2001), for instance, distinguishes among diffusion (one group encouraging others to adopt new ideas), adaptation (adjustment to a changing environment), innovation (the intentional introduction of new, tangible processes or procedures), and reform (change encouraged from above or outside forces), and notes that researchers can focus on the causes, degree, timing, scale, focus, intentionality, responsiveness, and target of change. Although we began our study with no formal definition of organizational change in mind, we were interested in certain kinds of change. Most importantly, we were interested in changes that extended beyond the knowledge and activity of individual museum staff members. NISE Net had devoted considerable resources to professional development for the staff members of its partner museums, and the impacts of that work were being documented.

This study was intended to build on and complement the Network's summative evaluation of its impacts on museum professionals by looking at the broader impact of participation in NISE Net—the impact on the organization as a whole rather than on individual staff members. We were, therefore, interested in the extent to which information from NISE Net was widespread among staff members. But, in keeping with the conceptual framework we describe below, it was not enough for staff members to acquire new knowledge; organizational change requires that they incorporate new ideas into practice. Therefore, we looked for ways that participation in NISE Net led organizations to change their ongoing and routine practices. Finally, we were interested in changes that were likely to be sustained over time, an indication that they had become part of the organization's new way of doing things. We were aware that our conclusions about sustainability would need to be tentative—because of the scope and timeline of our study—as it may take more than a few years for new ideas to find the conditions that enable their enactment, and new practices may be discontinued after the initial enthusiasm or other forms of support for them wanes.

A.1.2 BACKGROUND LITERATURE

We began with a broad definition of organizational change because—even though organizational change has emerged as an area of research rich in both theory and practice over the past 20 years—there has been little research examining organizational change in museums. Three studies (Loomis, 2009; Matelic, 2008; Reich, 2014) illustrate the kinds of approaches researchers have taken and their conclusions, and the limitations of their work for our study.

Based on interviews with staff members, Matelic (2008) followed change in seven history museums and distilled her findings down to several "ground rules" and "key understandings" (p. 8). First among them is that museums need to go outside of research on museums, due to the lack of empirical study on the subject, and look for meaningful data and useful models of organizational change in other fields. With respect to organizational change in museums and historical institutions, she found that change often comes at a cost to stakeholders in the form of stress and dissatisfaction, but ends with feelings of satisfaction and recognizable improvements. Successful change, according to Metalic, requires leadership that can appeal to what stakeholders value and can empower others to share the leadership role.

Reich (2014) looked at organizational change in science museums and the inclusion of people with disabilities in informal learning. She found that successful organizational change is embedded in multiple departments across a museum and requires a willingness to experiment and be reflective. When organizational change involves serving a particular community, Reich's findings suggest the importance of involving the community in the organization's work and emphasizing to staff that being inclusive to this group in turn benefits the whole museum. She found that sustainable change requires embedding the desired change into the museum's internal communications, professional development, and large projects.

Loomis (2009) examined how societal and organizational assumptions about science learning are manifested in exhibits and practices of a science center and, consequently, influence the kinds of teaching and learning activities that take place at the exhibits. She noted that traditional museums "are products of the social and historical environments in which they developed . . . and convey values about the nature of science, the nature of learning, the role of

citizens in science, and the role of science in society" (Loomis, 2009, p. 2). For this work, she focused on the Exploratorium, located in San Francisco, CA. By examining historical shifts in views about (a) science learning and teaching and (b) the Exploratorium's goals and offerings, she identified tensions associated with the conflicting aims to promote science for all and to privilege the authority of scientific knowledge.

Matelic, Reich, and Loomis have provided important information about change in museums, and we built on their work in various ways. For instance, in Reich's work we found a model for conducting case studies in science museums, Matelic pointed to the importance of understanding leadership's role in organizational change, and Loomis' focus on the centrality of goals, values, and social structures is at the heart of our analysis. But their work provided only limited guidance for studying museums in a national network like NISE Net. As alluded to above, this study differs from most other investigations into organizational change in at least two ways:

- First, most studies of organizational change begin by clearly articulating the types of change organizations are seeking. In contrast, we chose not to limit our investigation to pre-existing notions of the kinds of changes that might occur; rather, throughout our data collection and analysis we remained open to the possibility of emergent, unexpected, and various changes among the participating museums.
- Second, most studies of organizational change have focused on organizations in which the need for change was clear, perhaps due to financial concerns, new government policies, or a mandate from the organization's leadership. In contrast, as a loosely-structured network of independent organizations that chose to participate in the NISE Network, we recognized that museums had many reasons—often unrelated to organizational change—for joining NISE Net. Thus, organizations' goals for participating in NISE Net and for engaging in change were topics for investigation.

Through an in-depth analysis of six partner museums, this study enhances the informal science education field's understanding of how organizations participating in a national network learn and incorporate new practices into their work, and how networks can employ strategies that facilitate and foster learning among their member organizations.

A.1.3 CONCEPTUAL FRAMEWORK

Our research approach was guided by a conceptual framework based on the notion of communities of practice, developed by Etienne Wenger (1998a; Lave & Wenger, 1991), which has been used to show how change results from the interplay of groups with distinct but overlapping histories, values, goals, and practices.[1] The communities of practice approach suggests that learning is not an individual process and that organizational learning is not just the aggregation of the learning of individuals. Rather, learning occurs among groups of people who are bound together because they participate jointly to solve problems and help each other to accomplish their goals and make sense of their experiences. Overall, communities of practice can be defined as "groups of people who share a concern or a passion for something they do and

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[1] For an application to a museum setting, see Kisiel (2010).

learn how to do it better as they interact regularly" (Wenger-Trayner & Wenger-Trayner, 2015, p. 1).

In our work, we consider NISE Net and each of the participating museums to be a distinct community of practice. Communities of practice are distinguished by three characteristics:

- **Joint enterprise or "what [the community] is about."** According to Wenger (1998b), a community's joint enterprise is "understood and continually renegotiated by its members" (p. 2). This includes the community's set of goals that are regularly agreed upon by the group. For example, the participants in the partner museums in our study are bound together by a common set of goals—to bring science to their public audiences—although each museum had its own version of this goal and other more specific goals that motivated their particular community.
- **Mutual engagement or "how [the community] functions."** According to Wenger (1998b), mutual engagement "bind[s] members together into a social entity" (p. 2). This occurs when a group of people work together to accomplish some task and to make sense of what they do. The community mutually develops practices and tasks in the context of its own circumstances. For example, each partner museum has its own practices for developing and delivering programs, raising funds, and sharing information with each other.
- **Shared repertoire or "what capability [the community] has produced."** According to Wenger (1998b), the shared repertoire includes "communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.) that members have developed over time" (p. 2). These are the resources—both physical and otherwise that communities produce as they work together and that become available for them to use in their practices. As communities do their work, they modify and repurpose their resources and create new ones. For example, each participating museum has developed sets of hands-on materials, instructional guides, policies and styles for interacting with visitors, and even its own vocabulary that it uses in its work.

Communities of practice accomplish their work through the processes of **participation** and **reification** (Wenger, 1998a). As inherently social organizations, members of a community share information, perspectives, and strategies as they collaborate to achieve their aims. In doing so, they establish ways of acting and talking that may become part of the practice. Sometimes these ways of working are reified—made concrete as they are formalized and preserved. NISE Net's extensive online library of lesson plans, guidelines for holding adult seminars, and strategies for using improvisational techniques in staff development are examples of the reification of practices initially developed through participation. Wenger notes that participation and reification provide two avenues to promote change within communities of practice: "1) You can seek, cultivate, or avoid specific relationships with specific people. 2) You can produce or promote specific artifacts to focus future negotiation of meaning in specific ways" (1998a, p. 91).

NISE Net used both avenues to promote changes within the partner museums. The Network encouraged new forms of participation by, for instance, suggesting museum staff members create partnerships with scientists and providing both in-person and virtual meetings that brought together staff members from a wide range of organizations. NISE Net also made

numerous artifacts available to partner museums, such as the *Nano* exhibition and NanoDays kits that included detailed presentation information that may have led partner museums to change their offerings and ways of interacting with the public.

A primary focus of our data collection and analysis, therefore, was to understand with whom and how museum staff members interacted and shared information with each other, and how the artifacts produced by the Network led to changes at each site. Also included in our analysis are the university and industry scientists and educators who partner with the museums we studied to accomplish work related to nano.

These external partners are themselves members of communities of practice with their own goals, values, histories, resources, and ways of doing things. Our focus on organizational change among the partner museums, though, did not require a comprehensive analysis of their communities of practice. Rather, we focused on just a few aspects of their work—especially their goals, resources, and constraints—to help us understand the nature of their interactions with staff members from the partner museums. We were especially interested in the interactions among the three groups—the Network, the external partners, and the partner museums. How do they overlap in terms of joint enterprise, mutual engagement, and shared repertoire, and where are there potential tensions?[2]

Although learning is a central aspect of each community of practice, the interactions at the boundaries between communities are especially powerful sources of innovation and change by bringing the characteristics of one or more communities into contact with other communities. These interactions are facilitated by **boundary objects** and **brokers**—artifacts and people who move between two or more communities (Wenger, 1998a). For instance, when the Network developed, tested, and made available programs and instructions for delivering them, they created boundary objects that traveled between the two communities. These objects often included scripts that partner organizations may have used, the wording of which typically reflected specific ways of interacting with the public based on values and beliefs about what is important to teach and how to teach it. These boundary objects are a means that one community can use—intentionally or not—to influence change in another community. Although, it is important to note that the partner museums always interpret the objects from another community based on their own history, goals, values, practices, and so forth. Similarly, brokers are people who participate in more than one community, such as staff members from partner museums who attended a professional development workshop offered by the Network, or museum educators who collaborated with local scientist partners to create public programs. In this research, we are interested not only in what was learned by brokers, but what happened to their new knowledge when they returned home: What were the social and structural conditions that facilitated the spread of their knowledge so that it could lead to widespread and sustainable organizational change?

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[2] Relations between communities of practice are always bidirectional. Partner museums are not solely influenced by the Network and external scientists and educators, but also have an impact on them. Although we recognize these reciprocal influences, the focus of our study—change among the partner museums—emphasizes the impact on (rather than of) the partner museums.

CHAPTER 2. METHODS

We conducted a longitudinal case study of six museums to look at the processes and conditions that facilitate or hinder sustainable organizational change as a result of participation in the NISE Network. For this study, data was collected at each site twice, separated by 18 – 20 months. We decided that, rather than attempting to collect data that are representative of the entire NISE Network, we would select sites that were most likely to exhibit sustainable organizational change due to participation in NISE Net. To do this, we chose museums that had strong connections to and were highly involved in NISE Net. Looking at active sites allowed us to see both hindrances and facilitators of change, whereas, if we had chosen less involved museums, it may have been difficult to see change or understand enabling factors. Museums were considered highly involved if they had a history of hosting NanoDays events, had applied for a mini-grant or the *Nano* exhibition (or both), and had staff members who attended NISE Net professional development meetings and workshops.

Our team went through a series of steps to select research sites. Early in 2012, we met with the Community workgroup to ask for suggestions about sites where a variety of changes related to NISE Net involvement were likely to occur. Using these recommendations, the team searched the Network's partner database (QuickBase) to identify highly involved museums that varied in terms of size, setting, and annual attendance. We also looked for diversity in terms of NISE Net regional hub affiliation. Figure 1 identifies how NISE Net divided the country into seven geographic areas, or hubs, which had specific Regional Hub Leaders available to support museums in that region.
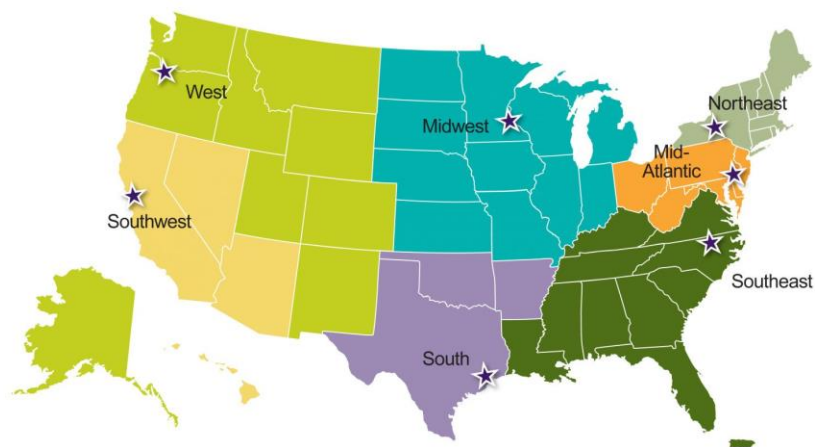
Figure 1. NISE Net Regional Hub structure (NISE Net, 2014a)

In the summer of 2012, we contacted senior staff members at potential sites to see if they would be interested in participating in the study. If the sites agreed to participate, we identified a contact person at each site—usually the staff member most involved in NISE Net—and a contract was finalized. As stated in the contract, museums received $500 for each site visit as an incentive and a token of our appreciation. Ultimately, the six participating museums were each from a different regional hub and included medium and small museums in both urban and rural areas.

A.2.1 OVERVIEW OF METHODS: QUALITATIVE AND LONGITUDINAL[3]

Because of the "richness and holism" that qualitative data provide (Miles & Huberman, 1994, p. 10), we selected a qualitative case-study approach. Case studies allow researchers to look for themes at individual organizations and then identify commonalities across the group of organizations to derive larger, more general conclusions (Stake, 2006). In choosing case studies, we built on other research that has shown them to be an effective method for looking at organizational change and the elements that facilitate or impede it in museums (e.g., Loomis, 2009; Reich, 2014). Furthermore, this method provided a high level of "local groundedness" for the research because data about each of the museums were collected on site (Miles & Huberman, 1994, p. 10).

We chose to conduct a longitudinal analysis occurring over multiple years to increase the likelihood that we would observe a variety of changes. We were interested in changes related to participation in NISE Net that occurred both prior to our first site visit and between the two visits. The longitudinal method also allowed us to look for changes that had a limited lifespan (i.e., were abandoned before the second site visit) and for changes that looked as if they would be sustained because they had already lasted several years.

We used several methods to construct each case study, including interviews with staff members, volunteers, and scientist partners; onsite observations of meetings and programs; and online surveys of staff members. By using a variety of data collection methods, the research team triangulated data sources to create a reliable and comprehensive view of each case (Miles & Huberman, 1994).

Data were collected through two rounds of site visits to each museum: one in the Fall of 2012 and one in the Spring and Summer of 2014. Each site visit lasted from three to five days. During the first round of site visits, when possible, multiple researchers visited the sites together. This approach served several functions including increasing researchers' comfort with the data collection methods and, ultimately, enhancing the analysis because multiple team members were familiar with the sites. Thus, for three of the initial six site visits, two researchers were on site together collecting data. During round two of site visits, each visit included only one member of the research team. This team member was always someone who had been to that partner museum during the first round of visits.

A.2.2 METHODS FOR UNDERSTANDING THE STUDY MUSEUMS AS COMMUNITIES OF PRACTICE

A.2.2.1 Procedures and instruments

Prior to the first site visits, researchers asked the contact person at each site to send an online **pre-visit survey** to all staff members and volunteers. Since we were interested in

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[3] In addition to the methods described here, we included two questions in the 2013 NISE Net Annual Partner Survey—an online survey sent to more than 1200 individuals active in the NISE Network—to gain information about how and with whom staff members in partner museums share information about NISE Net within their organizations. See B.5.2.1 for details.

interviewing staff members and volunteers who varied in their involvement in NISE Net and nano-related activities, the surveys asked individuals about their knowledge of NISE Net and nanoscale science, engineering, and technology, and about their personal involvement in the Network. Although not every potential interviewee returned a survey, this step helped us select people to invite for interviews.

During both site visits, **in-depth interviews** were conducted with staff members, volunteers, and administrators. To get a sense of how NISE Net had an impact on each organization and the nature of organizational changes over time, the interviews were conducted with people who had varying levels of NISE Net knowledge and played diverse roles within the organization. Beyond looking at responses to the online surveys, interviewees were identified based on discussions with regional hub leaders and recommendations from each site's contact person. We used a semi-structured interview format during both site visits so that researchers could probe about areas of particular interest or skip over areas with which participants had little involvement or knowledge. Interviews ranged from about 20 minutes to two hours depending on the individual's knowledge of the organization's involvement in NISE Net and nano-related activities. Before beginning each interview, informed consent information was reviewed and participants had the option to agree or disagree to the interview and having it audio-recorded.

The interviews covered several broad topics based on other research in organizational change studies and this project's particular community of practice framework. We sought to learn about how each research site functioned as a community and how they received, interpreted, and used information from NISE Net. We developed an interview for the first site visit that covered the following areas:

- The interviewee's background, including information about his or her job, department, and length of time at the museum
- The interviewee's understanding of the museum's educational goals
- The interviewee's understanding of NISE Net's aims
- The impact of participation in NISE Net on the museum
- The history of the museum's involvement in NISE Net
- The interviewee's personal involvement in NISE Net activities and use of Network products
- The interviewee's attendance at NISE Net meetings and workshops
- The interviewee's understanding of NISE Net's influence on the museum beyond nanoscale science, engineering, and technology
- The interviewee's understanding of NISE Net's influence on partnerships with scientists and educators outside the museum

We adapted the interview for the second site visit. Site Visit 2 interviews, especially when conducted with participants who had been interviewed during Site Visit 1, focused on changes related to the museum's context, its nano-related work, NISE Net's impact on the organization, and whether or not the nano-related efforts were expected to continue in the future. A copy of the interview instrument that was used with repeat interviewees on Site Visit 2 can be found in Appendix A. Interview data also were collected between site visits in the form of phone check-ins with each site's contact person.

In-depth external partner interviews were conducted by phone if museums had partnerships related to nanoscale science, engineering, and technology. We employed a similar semi-structured interview format when talking with external university and industry partners to gain an understanding of these relationships and how NISE Net may have had an impact on their work with the museums in our study. These interviews covered:

- The partner's background
- The history of the partnership
- A description of the partnership and its goals
- The partner's understanding of NISE Net's aims
- Perceived benefits of the partnership for both the partner and the museum
- Plans for sustaining the partnership

Follow-up interviews with partners took place in Fall 2014. For external partners who were interviewed after both site visits, the second interviews covered similar topics but focused on changes that occurred over the last year and a half.

On site, researchers conducted **observations** of meetings and programs to gain a deeper understanding of each organization's culture and practices. For each observation or meeting, researchers took notes to capture the type of museum professionals or audiences who attended, the range of topics discussed, and whether or not any NISE Net connections or nanoscale science, engineering, and technology references were made. Prior to each meeting, we informed participants that we would like to observe and take notes and gave them the opportunity to confidentially object to our presence; if anyone objected, we did not attend the meeting. Table 1 contains information about the amount and various types of data we collected.

Table 1. Data collected during site visits

Type of data	Number of survey responses, interviews, and observations
Interview Data	
Pre-surveys for Site Visit 1	54
Site Visit 1 Interviews	67
Site Visit 2 Interviews	47
Observation Data	
Site Visit 1 Meetings	10
Site Visit 1 Activities	13
Site Visit 2 Meetings	8
Site Visit 2 Activities	5

Note. Site Visit 1 interviews included 3 external partners. Site Visit 2 interviews included 6 external partners. There were 28 participants who were interviewed in both Site Visits 1 and 2.

A.2.2.2 Data analysis

Using qualitative procedures, the primary aims of our data analysis were to identify themes related to our research questions—the kinds of organizational change that museums experienced as a result of their participation in NISE Net, and the conditions that facilitated and impeded those changes—in each site and across the sites. Following Site Visit 1, we began a period of data reduction by "selecting, focusing, simplifying, abstracting and transforming the data that appear in written-up field notes or transcripts" and identified several preliminary themes and findings (Miles & Huberman, 1994, pp. 10-11). We undertook a round of analysis of Site Visit 1 data to compile a set of themes that became the focus of several team discussions, thereby deepening our understanding of how the themes applied to each museum and across the sites. We then used these themes to organize our analysis of Site Visit 2 data, looking for their appearance and modification in the second round of interviews, while remaining open to the possibility of developing new themes. A summary of our analytic process follows.

After the first round of site visits, initial steps in the data reduction process included the creation of site stories for each of the six sites, where each member of the research team focused on the two museums he or she had visited. These stories summarized each museum's history, practices, resources, and the researcher's reflections about the visits. We also prepared written summaries of two key interviews from each site. The stories and interview summaries were distributed and read by other members of the research team. These became the focus of meetings, in Spring and Summer of 2013, in which team members learned about the museums they had not visited, discussed emergent themes, posed questions, and made comparisons across sites.

After discussing and reflecting on the first round of site visits, we developed an initial coding scheme to analyze the Site Visit 1 data. We used both "top down" and "bottom up" processes to develop and refine the coding scheme (Miles & Huberman, 1994, p. 262). That is, we developed broad categories of codes (top down) based on the communities of practice conceptual framework, which also had guided the major sections of the interview. We then applied these categories to the transcripts looking inductively (bottom up) to add new codes at various levels of specificity to improve the scheme's ability to capture details and distinctions. While performing this coding, we also created memos to capture our reflections on the data, connections to other sites or themes, and potentially interesting stories. We used the qualitative data analysis software Dedoose (SocialCultural Research Consultants, LLC., 2016), which has the capabilities to create, combine, and aggregate codes and subcodes, and to link memos to specific data points. The large categories for the first round of coding included:

- **Context**—Any contextual information about the museum, including its history and surrounding area
- **Goals**—Comments about educational and institutional goals for the museums, NISE Net, and scientist partners and descriptions of how they were being accomplished by the organizations and individuals
- **NISE Net Knowledge**—Comments indicating knowledge of NISE Net

- **NISE Net Impact**—Comments about the effect of NISE Net on people or organizations, including anticipated impacts
- **Information Flow**—Comments about how information is shared and spread within and between the Network and partner organizations as well as from the museums to their public audiences and with scientist partners
- **Change**—Comments about change, both related and unrelated to NISE Net

During this first round of coding, most of these large coding categories also had subcategories of codes. Subcategories were created to allow researchers to better understand trends occurring within and across museums. Subcategories were based on community of practice theory and our initial understanding of the themes emerging from the data. For instance, within the broad category of "NISE Net Impact," we separated out NISE Net's impact on the museum, university, and individual. As an illustration, the subcategories for "NISE Net Impact: Museum" are described below:

- **Infusion**—NISE Net's impact on the inclusion, adaptation, or adoption of nano content or NISE Net practices into museum offerings
- **Partner**—NISE Net's impact on a museum partnership
- **Public**—NISE Net's impact on the museum's visitors
- **Engage staff**—NISE Net's impact on how museum staff members engaged with each other
- **Engage public**—NISE Net's impact on how museum staff members engaged with the public such as through using new techniques, etc.
- **Staff**—NISE Net's impact on museum staff members (outside of the interviewee)
- **Obstacles**—Barriers preventing NISE Net from having a greater impact on the museum
- **None**—NISE Net did not have (or does not appear to have) an impact on the museum
- **Other**—Any other way NISE Net had impacted the museum

A second round of coding the Site Visit 1 interviews led to the creation of additional sub-codes, detailed memos, and the refinement of themes for further exploration. Each member of the research team was assigned a couple of the large coding categories to explore; this entailed reviewing all interview excerpts that received a specific code, proposing themes for the category that applied within and across the six sites, presenting the information to other members of the team, and writing a summary of the coded excerpts—including reflections on their significance for organizational change—for each site. We combined these detailed documents—each focused on a specific part of the coding scheme—and supplemented them with contextual information taken from the site stories we had previously developed, to create a case summary for each site (Miles & Huberman, 1994).

To analyze Site Visit 2 data, we developed a new coding scheme (again using Dedoose) that built on the themes we identified in the Site Visit 1 interviews and observations. The primary focus was to explore the preliminary themes we developed in our analysis of Site Visit 1 data noting changes that had taken place between visits and identifying potential new themes. Thus, for instance, the Site Visit 1 coding category "Context" became "Changes in Context from Site Visit 1 to Site Visit 2." New sub-codes for some of the categories reflected preliminary

cross-case themes that we wanted to explore in the Site Visit 2 data. For instance, sub-codes under "Impact of NISE Net products" included (among others):

- *Nano* exhibition increasing staff knowledge
- NanoDays kits being used throughout the museum
- NanoDays events with many museum staff involved
- NanoDays events with few museum staff involved
- NanoDays events as a catalyst for partnerships
- Mini-grant projects, possible sustained impact
- Mini-grant projects, limited impact

We applied these codes to interviews from Site Visit 2 and, as we were coding, added to the case summaries we had prepared for each site following the first site visit, focusing on changes that had occurred. The research team discussed whether the themes we had identified in Site Visit 1 were or were not still applicable to Site Visit 2, how the sites had changed between visits, and any new themes that had arisen, again focusing on the individual sites, what the sites had in common, and how they differed. Through this process we honed in on a set of findings and identified supporting data for presentation in this report.

A.2.3 METHODS FOR UNDERSTANDING THE NETWORK CORE PARTNERS AS A COMMUNITY OF PRACTICE

A.2.3.1 Procedures and data analysis

According to our conceptual framework, Network Core Partners —composed of the museum professionals and associated educators, scientists, and researchers from roughly 14 organizations who organized and ran the NISE Net and developed products for distribution to partner museums—were a community of practice with its own history, values, resources, and goals. Therefore, to understand how participating in NISE Net had an impact on museums, it was necessary to examine the topics, ideas, values, and related practices that the Network made available to its partner museums. Data collection to gather this information included **mining a variety of sources** with information about the values, content, and practices that NISE Net has made available such as the Network's website, previous evaluation reports, and the goals and agendas for a variety of NISE Net gatherings (e.g., workshops and regional meetings).

After noting the topics, ideas, values, and practices made available to partner museums by NISE Net, a **data check** was carried out with one current and one former member of the Network Core Partners' executive and operating groups. The result of this conversation was the creation of a matrix listing the topics made available to partner museums (e.g., nano content, evaluation techniques, and information about science-museum partnerships), the practices corresponding to each topic, the ideas and knowledge around the topics that had been created by the Network, and the values being conveyed to partner museums through the topics. This matrix can be found in Appendix B.

CHAPTER 3. THE NISE NETWORK AS MULTIPLE COMMUNITIES OF PRACTICE

The NISE Network consisted of several groups of organizations and individuals, and as these various groups interacted they created opportunities for change. In these interactions, group members were exposed to alternative ideas and practices that they may have brought back to their organizations, shared with their colleagues, and incorporated into their own work. Because professionals may have been introduced to new ideas from these various groups, in our analysis of organizational change it was important to have a sense of these different communities that comprised the NISE Network. Below we define the various groups discussed in this report and then provide background information about the communities of practice we studied—the Network Core Partners and the six partner museums.

The primary groups that we discuss in this report are the following:

- **The NISE Network** refers to all the organizations and individuals that have participated in the activities of the NISE Net. As of August 2015, the end of NISE Net's main funding period, the Network consisted of 595 organizations, including 352 museums (e.g., children's and science museums, science centers) and other informal educational settings, 203 university groups (e.g., scientists, educators, and outreach coordinators), and 43 organizations from industry and other settings.

- **Network Core Partners** consisted of approximately 14 organizations that received funding through the grant and whose staff members were responsible for running the NISE Network. These staff included educators, evaluators, program and exhibit developers, other museum professionals as well as a few external scientists. The Network Core Partners were structured into several working groups, which were responsible for developing materials and programs for distribution throughout the NISE Network, organizing meetings and professional development opportunities for members, and conducting evaluation and research studies of the NISE Network's accomplishments and processes. Another name for this group was Tier 1. The Network Core Partners also included executive and operations teams whose members set the direction of the Network and oversaw its functioning.

- **Partner Museums** included over 300 museums across the US who participated in the NISE Network's activities. Involvement ranged from being closely connected with the Network (e.g., hosting an annual NanoDays event, attending NISE Net's regional and Network-Wide Meetings and professional development workshops, using NISE Net materials to infuse their offerings with nano-related content) to more casual involvement with the NISE Network (e.g., looking for information on the Network's website, receiving NISE Net's digital newsletter). The six organizations[4] that we studied were all highly involved in NISE Net and were

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[4] Although some of the sites in this study referred to themselves as "science centers" we are using the term "museum" throughout the report as a general term to refer to the sites.

considered to be in Tier 2 of the Network. Organizations in this category were the primary recipients of Network resources and professional development opportunities.

- **Scientist Partners** are industry- and university-based scientists and educators; some of them were direct members of NISE Net and some were connected to the Network by collaborating with staff members of partner museums. Scientists and museum professionals may have, for instance, worked together to design and enhance museum exhibits or bring students to the museums to volunteer at nano-related events. Although the Network Core Partners encouraged these partnerships, they typically were formed and sustained through the efforts of the scientists and partner museum staff members.

To provide contextual information for the rest of the report, the next sections provide an overview of the types of messages and resources the Network Core Partners made available to partner museums and background information about each of our sites.

A.3.1 NETWORK CORE PARTNERS AS A COMMUNITY OF PRACTICE

We considered the Network Core Partners to be a community of practice, with a characteristic enterprise, engagement, and repertoire. As described in section A.1.3, each community of practice has a common set of goals (i.e. joint enterprise), shared practices (i.e. mutual engagement), and common resources (i.e. shared repertoire).The Network Core Partners' joint enterprise was organized around the shared goal of enabling researchers and informal science educators to foster public awareness, engagement, and understanding of nanoscale science, engineering, and technology. The forms of mutual engagement developed to accomplish this goal included structures (e.g., the network of partner museums) and strategies (e.g., professional development programs) designed to interest museum staff members in expanding their public offerings around nano and provide them with the tools necessary to do so. Shared repertoire included the talents of the people who constituted the Network Core Partners and the resources made available through the project's funding (e.g., materials disseminated to the partner museums, funds that allowed museum staff members to attend NISE Net gatherings or do specific nano work). For example, NISE Net made both tangible products, such as kits, and ideas, such as the importance of reaching underserved audiences, available to partner museums so that they could adopt and incorporate them into their work. Through these efforts, the Network Core Partners shared some of the core values of their community with the partner museums. In this section, we further describe the Network Core Partners as a community of practice and define the NISE Net products and professional development opportunities that will be discussed throughout this report. We worked with one current and one former member of the Network Core Partners' executive and operating groups to develop a matrix of the topics, practices, ideas, and values that the Network made available to its partner museums (Appendix B). Information about the NISE Net's offerings primarily come from its website (www.nisenet.org).

A.3.1.1 The main focus of NISE Net was nano content.

The NISE Network described itself as "a national community of researchers and informal science educators dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology" (NISE Net, 2014c, para. 1). Although the full NISE Network is comprised of over 500 museums and universities, it was led by 14 organizations. These lead museums and universities received direct funding through two National Science Foundation grants totaling over $40 million to develop informal education products, create professional development opportunities, and build the capacity of NISE Net partner organizations. The Core Partners, their products and ideas, guide the NISE Network.

To accomplish its mission, the Network Core Partners used vehicles such as educational products and professional development resources that conveyed specific ideas related to the Network Core Partners' goals, objectives, and values. The products developed and disseminated by the Network Core Partners acted as boundary objects, or artifacts that moved between communities. The Network's gatherings and professional development offerings were opportunities for brokers, or people who moved between communities, to cross from their museum community to the larger Network's community and bring back new ideas and goals, along with suggestions and strategies to accomplish them. The ideas and information embedded in the products, shared at gatherings, and included in programs imparted knowledge to the professionals in the Network's partner organizations about specific topics; foremost among them was nano content. In particular, NISE Net identified four key concepts to engage the public in nano: "(1) Nano is small and different, (2) Nano is studying and making tiny things, (3) Nano is new technologies, and (4) Nano is part of our society and our future" (Sciencenter, 2011, p. 3). By focusing NISE Net around nano, the Network Core Partners conveyed two messages: (a) informing the public about nano is an important, valuable endeavor, and (b) science museums and universities should play a role in educating the public about this topic.

A.3.1.2 Additional practices beyond including nano content that were encouraged by NISE Net included forming scientist-museum partnerships, using evaluation, engaging visitors in societal and ethical implications of science, and reaching underserved audiences.

Although nano content was at the forefront of NISE Net's work, the Network Core Partners also made other topics available to the partner organizations. Non-nano areas conveyed to partners through NISE Net products and professional development included information about the benefits of partnerships between museums and scientists, the use of evaluation to assess and improve public offerings, how to engage visitors in discussions about the societal and ethical implications of science and technology, and strategies for reaching underserved audiences. By emphasizing non-nano topics, the Network showed that it valued them and encouraged partner museums to make them part of their own practice. A description of each of these non-nano practices is provided below with an overview of how the Network Core Partners shared information or examples of these practices.

- **Scientist-museum partnerships** engaged museum staff members in collaborations with local university and industry science professionals to develop informal science education activities around nano. The Network Core Partners indicated that such partnerships can

"leverage [the researcher's and museum's] respective expertise and resources, while advancing the goals of research funding agencies," benefiting all parties involved in the partnership and "especially the prospective audiences" ("A guide to building partnerships," n.d.-b, para. 2). One way that the Network Core Partners encouraged partnerships was to provide information about how to initiate and sustain these connections, especially around the annual, national celebration known as NanoDays.

- **Evaluation**—or embedding evaluative thinking, ongoing data collection, and reflection into a museum's practice—was promoted by the Network Core Partners in the form of Team-Based Inquiry (TBI). TBI "is a practical approach to empowering education professionals to get the data they need, when they need it, to improve their products and practices and, ultimately, more effectively engage public and professional audiences" (Pattison, Cohn, & Kollmann, 2014, p. 5). The Network shared information about this process, in particular, through a guide and professional development workshops.

- **Societal and ethical implications of science and technology** involves engaging visitors in discussions about the costs, benefits, risks, and uses of science and technology, and how they are connected to society and our values. The Network Core Partners provided NISE Net partner organizations with strategies for engaging the public in conversations about the relation between nano and society through educational products and professional resources that were physically available in NanoDays kits or that were downloadable from the website, including the "Nanotechnology and Society Guide" (Wetmore, Bennett, Jackson, & Herring, 2013). These ideas were also presented to partner museums that participated in NISE Net's Nano & Society Workshops. Throughout this report, this content is often referred to as Nano & Society.

- The Network Core Partners focused on providing resources to help partners reach two **underserved audiences**: people with disabilities and people who speak another language than English (mostly Spanish speaking audiences). The Network Core Partners' focus on these audiences was evident in its use of the principles of universal design in the creation of NISE Net products and the translation of activities and exhibitions into Spanish. Moreover, through program workshops NISE Net emphasized how universal design was a way to make programs as accessible to the widest possible range of audiences, including visitors with disabilities. NISE Net also shared information about these practices through guides describing strategies for translation and creating accessible exhibits. Guides included the "Universal Design Guidelines for NISE Network Exhibits" (NISE Net, 2010), the "NISE Network Bilingual Design Guide" (Ostman, Maletz, Jensen, & Jackson, 2012), and the "NISE Network Translation Process Guide" (Jensen, Núñez, Garcia-Luis, Ostman, & Lindgren-Streicher, 2011).

A.3.1.3 Common NISE Net products and professional development opportunities ranged from free kit and exhibition materials to Network-Wide and regional meetings as well as workshops devoted to specific topics.

In this section we describe some of the NISE Net products (boundary objects) and professional development programs (opportunities for brokers to cross communities) that are mentioned throughout the report (see www.nisenet.org for more details). These were the

mechanisms by which the Network Core Partners shared information, values, and resources with the partner museums and, potentially, fostered particular kinds of change.

Common NISE Net boundary objects mentioned in this report include:

- **NanoDays** was "a nationwide festival of educational programs about nanoscale science and engineering and its potential impact on the future" ("NanoDays," n.d.-e, para. 1). This annual event began in 2008, occurred each spring, and was organized and implemented independently by NISE Net partner organizations. The Network Core Partners developed activities and made them available to partner organizations and encouraged organizations to form partnerships to facilitate and enhance their events.
- **NanoDays kits** include "hands-on activities and other educational materials designed to introduce the public to basic concepts of nanoscale science, technology, and engineering."(NISE Net, 2014b, p. 5) Partner organizations applied for NanoDays kits each year to help them implement NanoDays events at their site. In 2014, NanoDays kits were distributed to 250 organizations across the United States. All kit activities address nano content; some also address the societal and ethical implications of nano. The NISE Net "TBI Guide" was included in the 2014 NanoDays kit and most of the written materials for the public (e.g., signs and marketing copy) were in both English and Spanish.
- **The *Nano* exhibition** is a 400-square foot "interactive exhibition that engages family audiences in nanoscale science, engineering, and technology" (NISE Net, 2011, para. 1). A total of 93 identical copies of the *Nano* exhibition were distributed to museum partners free of charge. Along with addressing nano content, the exhibition also included some content related to the societal and ethical implications of nano and all labels are translated into Spanish. At times, it was referred to as the "mini-exhibition" by the Network and partners.
- **Mini-grants** up to $3,000 were awarded by the Network Core Partners "to support initiatives by NISE Net partners to engage their local audiences in nanoscience, engineering, and technology topics" ("NISE Network mini-grants," n.d.-f, para. 1). These mini-grants supported a wide variety of projects at partner organizations that satisfied at least one of three categories: new efforts to integrate nano into existing programming, new efforts to reach new or traditionally underserved audiences with nano programming, and new partnerships between museums and nano researchers.
- **The Nano Bite** was a monthly newsletter for NISE Net partners, with sections that included Network news, upcoming events, information featured on the website, partner highlights, and nano in the news.
- **The Online library of resources**, often used synonymously with nisenet.org, is a part of the NISE Net website that includes hundreds of programs, activities, and other resources that can be used to "provide educational experiences in a variety of contexts" ("About programs," n.d.-a, para. 1).

NISE Net opportunities for brokers to cross communities are collectively referred to as "gatherings" throughout this report. Gatherings attended by staff members from this study's six partner museums include:

- **Network-Wide and Regional Meetings** were in-person meetings that occurred over the 10 years of the NISE Network. In the later years of the Network, meeting opportunities alternated annually between a single large Network-Wide Meeting and multiple regional meetings taking place across the country.
- **The Nano & Society Workshops** occurred in 2012 and "focused on preparing museum educators to engage the public in conversations about nanotechnology and society. . . . The workshop provided specific training and skill-building in nano and society content, conversation facilitation, and improving and learning from professional practice (Team Based Inquiry)" ("Nano and society," n.d.-d, para. 1).
- **The Universal Design of Educational Programs Workshop** occurred in 2013 and was "intended for museum educators who develop and conduct educational programs or train those who do. Invited workshop participants had a hands-on opportunity to apply NISE Net's universal design guidelines to a current NISE Net program and collect feedback on their program from people with disabilities using the Team-Based Inquiry approach" ("Universal design," n.d.-h, para 1).
- **Online Brown-Bag Conversations** were professional development webinars that occurred a few times per year on differing themes. These were "professional development opportunities that allow[ed] educators and scientists to share and learn from each other" ("Online workshops," n.d.-g, para. 1). Presenters during these conversations included Network Core Partners and staff members from the partner museums. Topics ranged from "Tips for Hosting the *Nano* Mini-Exhibition" to "Partnerships to Reach New Audiences with NISE Net Mini-Grants."

A.3.2 PARTNER MUSEUMS AS COMMUNITIES OF PRACTICE

Our analysis of organizational change in museums participating in NISE Net was grounded in the specifics of each community of practice: What each community was trying to accomplish (i.e. joint enterprise), how they performed this work (i.e. mutual engagement), and what resources and constraints existed that facilitated and constrained change (i.e. shared repertoire). Through our two site visits, in which we interviewed numerous staff members and observed their meetings and programs, we came to understand how each museum's history and context interacted with NISE Net in ways that promoted or hindered organizational change. In this section, we provide brief descriptions of the six museums we studied. Although in subsequent chapters we provide additional information about the settings as they illuminate our findings, here we briefly introduce the museums in our study to provide a general sense of the contextual background of each organization.

Table 2 provides an overall depiction of each museum's Network participation including the number of years that each site held a NanoDays event, the number of mini-grants received, and the timing of when their *Nano* exhibition arrived. The table also provides information about the professional development opportunities attended by staff members. In addition to the meetings listed, staff members from the study museums participated in other NISE Net gatherings such as webinars or ASTC-related meetings.

Table 2. Overview of each study museum's participation in NISE Net

Study museums (in order of smallest to largest staff size)	Years presenting NanoDays events (as of 2014)	Number of Mini-grants	Arrival of *Nano* exhibition	Attendance at NISE Net Gatherings[a]			
				Network Wide Meetings (freq)	Regional Meetings (freq)	Universal Design Workshop	Nano & Society Workshop
STSC	6	2	Prior to SV2 [b]	2	2	No	No
YESM	7	1	Prior to SV1 [c]	4	3	No	Yes
PSSC	4	2	After SV2	3	2	Yes	Yes
OSSC	7	1	Prior to SV1	1	1	No	Yes
LPSC	7	1	Prior to SV1	4	3	No	No
CMSC	6	1	Prior to SV2	2	2	Yes	Yes

[a] Attendance is based on one or more staff members from an organization attending a gathering.
[b] SV2 stands for Site Visit 2, SV1 stands for Site Visit 1
[c] *Nano* was on loan to another museum during Site Visit 2.

What follows is a description of the sites arranged in order from smallest to largest based on the number of staff. For each one, we include information about its size, location, and public offerings; its mission; and its nature of involvement in NISE Net.

A.3.2.1 Small Town Science Center (STSC)

General overview

STSC is a small science center located in a small city (population about 12,000) in a rural part of its state. The city is home to a campus of the state college system and a popular area for outdoor leisure activities (hunting, fishing, and hiking). At the time of Site Visit 1, STSC employed seven paid staff members, including an executive director who had started a few months earlier, and a few volunteers. The previous executive director founded the museum in the 1990s and retired shortly before our visit. By the second site visit, three paid staff members had left and one was working part-time on weekends; there were plans to hire several additional part-time workers. STSC had an eclectic mix of science exhibits purchased or donated from other museums and universities or constructed by staff members and volunteers; they also had a wide array of live animals. The science center offered a weekly afterschool science club and a program for preschool children, several camp programs during the summer, and on- and off-site programs for schools, scouts, and other groups. By Site Visit 2, STSC had started a new, free program, called Saturday Science, which brought local scientists, engineers, and business people to present about science.

Mission

STSC's mission was tied to characteristics of its location. Several staff members noted that STSC was in an economically depressed region of the state. Staff members expressed concern about the quality of science teaching in the area's schools, and noted that there were few opportunities in the area for young people to participate in out-of-school science activities. As a result, staff members said their primary goal was to get youth engaged and excited about science, to overcome the dislike and fear of science that was, they believed, a common outcome of how science is traditionally taught in school. To achieve this, they kept their admission and program fees low, hosted several free events, and accommodated requests for a wide range of programs, developing new topics when needed. Because staff members were needed to facilitate visitors' interactions with animals, staff members often stayed with visitors throughout their time at STSC; this was an opportunity to engage visitors in activities and discussions aimed at engendering positive attitudes about science and the ability to engage in scientific ways of exploring and thinking.

Nature of NISE Net involvement

STSC has been involved with NISE Net since 2009 when it hosted its first NanoDays event. Most of STSC's interactions with NISE Net and nano-related work have been through one staff member who had attended several regional and Network-Wide Meetings. Other staff members have participated in an online brown bag webinar. STSC received two mini-grants from NISE Net. For this work, the main NISE Net contact was developing a nano-themed exhibit about ferrofluids.

During Site Visit 2 they were hosting the *Nano* exhibition, on loan from another NISE Net partner museum, although it was placed in a part of the museum not frequented by many visitors. In general, there appeared to be less excitement among staff members about their participation in NISE Net on Site Visit 2 than there was in the first site visit.

A.3.2.2 Young & Evolving Science Museum (YESM)

General overview

YESM is a small science museum located in a small city (population about 20,000) in a rural area of its state. The city is home to a state college campus and is a popular retirement community for people from adjacent states. YESM employed approximately 12 paid staff members, some of whom were part-time. A new executive director began about 10 months prior to Site Visit 1 and there was some staff transition soon after, including the departure of several staff members who had participated in the NISE Network. The museum consisted of a variety of science-themed, interactive exhibits—most were purchased but a few of them were built by volunteers—and an occasional traveling exhibition. There was also an area for toddlers, an auditorium, and a lab room, or a space similar to a high school science classroom. Typical visits

for school groups included a live presentation in the auditorium, a guided activity in the lab room, and time to explore the exhibits. At the time of the first site visit, YESM offered a monthly themed weekend, which included hands-on activities and special programs, including presentations by local scientists and engineers, around a specified topic, often related to current events. They also offered an afterschool science club for girls and several summer camps.

Mission

Staff members at YESM said their mission was to create a sense of wonder and excitement about the world by engaging visitors in hands-on, interactive experiences. Some staff members talked about the museum's relationship with the local school district, suggesting that schools did not provide students with adequate science instruction, in part because teachers were unfamiliar with science and uncomfortable teaching it. As a result, it was important for YESM to educate children about science and to provide teachers with experiences and methods that would improve their classroom instruction. Additional goals included reaching more Spanish-speaking residents and providing events for adults. By Site Visit 2, YESM's mission was evolving to include more of a curiosity-based learning approach and a focus on tinkering spaces.

Nature of NISE Net involvement

YESM has been involved with NISE Net since 2008, when they hosted their first NanoDays event as one of the monthly themed weekends. Due to staff turnover, a variety of staff members have attended NISE Net related gatherings including regional and Network-Wide Meetings and the Nano & Society Workshop. They were awarded a mini-grant, which they used to develop a nano-related theater program and an afterschool program. During Site Visit 1, they were hosting the *Nano* exhibition, which, according to their agreement, was on loan to a partner museum during Site Visit 2.

Interviews with staff members during Site Visit 2 indicated considerably less interest in NISE Net's approach and what it could offer them compared to the first site visit. They were reducing the number of themed weekends they offered each year, potentially cutting their NanoDays celebration. Besides having the *Nano* exhibition out on loan, the nano-related theater program had not been performed since the staff member who developed it had left the organization (over a year prior), and the museum's leadership had decided against applying for another mini-grant because the museum's senior staff could not justify devoting staff time to developing a proposal for relatively little possible funding.

A.3.2.3 Pursuing STEM Science Center (PSSC)

General overview

PSSC is a medium-sized science center situated in a small-to-mid-sized city (population about 65,000) that is not known as a place of science and industry but rather as a leisure

destination. The science center also has a sister museum focusing on history, and several of the organization's roughly 10 full-time staff members worked for both locations. Besides these staff, PSSC also had two to three part-time educators. The science center had indoor and outdoor space which included areas for traveling exhibits and pre-school audiences. One main focus of the science center's exhibits and programming was local animals. The organization was also in the process of developing an exhibit about local water systems. Programming at PSSC included summer camps and frequent events at local schools.

Mission

In the past few years, PSSC worked hard to be seen by the public as a science center rather than a children's museum. Toward this end, PSSC engaged in a rebranding process in which they became completely STEM-focused. This change was often attributed to the director and the hiring of a new manager of the education department. The museum's STEM-focused mission was evident on both site visits. For example, they replaced old exhibits, built or purchased numerous new exhibits, and reworked and expanded their educational programs. By Site Visit 2, they had greatly increased the amount and attendance of school and public programming and had added substantially to their exhibit floor. This museum has become a STEM leader in its community, creating a small network of schools, museums, and a local university to coordinate public STEM events in the area.

Nature of NISE Net involvement

PSSC was a more recent NISE Net member, obtaining their first NanoDays kit in 2011, and had been a very involved partner ever since. It received two mini-grants to build a nano-themed exhibit, which was ultimately accompanied by the *Nano* exhibition. Two staff members attended several NISE Net professional development events, including regional and Network-Wide Meetings, the Nano & Society Workshop, an inclusive audience workshop, and several brown bag webinars.

PSSC appeared to become more involved in NISE Net from Site Visit 1 to Site Visit 2; between visits they were awarded a second mini-grant to expand their nano exhibit space and add nano into their summer camp and school outreach programs.

A.3.2.4 Outreach & School-focused Science Center (OSSC)

General overview

OSSC is a small science center in a medium-sized city (population about 200,000) that is home to several medical facilities, local colleges, and a few branch campuses of larger universities. Situated in a metropolitan region, the surrounding area is rural, and some visitors travel from out-of-state to visit the science center. The center had about 11 full-time staff members and roughly 15 part-time educators whose primary tasks were to engage visitors in the

galleries and handle other front-desk and on-the-floor responsibilities. The science center exhibits covered a range of science topics and were hands-on and interactive. The science center had lab space and also offered shows in their auditorium and theater. Besides having permanent and changing exhibitions, OSSC offered several large-scale events and theme-days, various outreach efforts in the local community, school-related activities, and summer camps.

Mission

OSSC's overarching mission was to combine science learning and fun via hands-on interactive experiences that inspire curiosity and inquisitiveness. In addition, supporting the regional school districts was a particularly important goal. As of Site Visit 2, they had seen an increase in attendance by school groups and continued to offer several initiatives aimed at local schools, such as providing school membership programs for low-income families. OSSC had also been working to attract older students and adult audiences through various programs such as after school and evening events. OSSC's commitment to staff interactions with guests was illustrated through the role of their part-time educators, who were expected to engage visitors in demonstrations and hands-on activities when at the museum or representing OSSC off-site.

Nature of NISE Net involvement

NISE Net involvement for this science center included hosting NanoDays events since 2008, obtaining a mini-grant to offer nano-related summer camps, and hosting the *Nano* exhibition. A couple of staff members attended regional and Network-Wide Meetings during 2008-2012, although no staff member attended a NISE Net meeting since the Nano & Society Workshop. In the past, this science center worked with a local nano scientist partner on several of their NanoDays celebrations.

From Site Visit 1 to Site Visit 2, several changes occurred in OSSC's nano-related work. These included less frequent use of nano activities by part-time staff on the floor and in outreach events, and the departure of a staff member who had been to the Nano & Society Workshop. However, between the two site visits, nano had been added to a few of their lab and school demonstrations.

A.3.2.5 Local Partners Science Center (LPSC)

General overview

LPSC is medium-sized science center situated in a rapidly growing mid-sized city (population about 120,000) that is home to multiple research-oriented colleges and universities and local manufacturing industries. About 20 full-time and several part-time staff members were employed at LPSC. A notable structural aspect of LPSC was the difference between the Education department, which dealt mostly with school audiences and did programming on weekdays, and the Guest Experience department, which was public audience-oriented and took

over programming on weekends. All of the science center's exhibits and programs were STEM-focused and almost all of them were created in collaboration with, or using funds from, local partners. LPSC had begun to take on larger traveling exhibitions connected to their yearly content themes twice per year. LPSC had grown greatly in terms of their school programs, including both outreach and in-house school workshops.

Mission

LPSC's focus on serving student audiences was connected to one of the science center's main goals: to inspire local students to pursue STEM careers in the region. This was a rather new goal during Site Visit 1 and was mostly attributed to the CEO at the time; however, it remained a strong goal two years later, even after the CEO had left the museum. LPSC was working toward accomplishing this goal by adding career connections whenever possible—including them in their school fieldtrips, outreach programs, and on the exhibit floor. LPSC staff members also strongly valued community partnerships, both with local industries and university researchers because, among several benefits, partnering helped connect students with local STEM careers.

Nature of NISE Net involvement

LPSC was an early NISE Net partner, holding their first NanoDays event in 2008. They received a mini-grant during the first batch and created two nano programs. They have hosted the *Nano* exhibition since 2012. The museum had three partnerships with local researchers around nano, for which NISE Net plays varying roles. One staff member attended all regional and Network-Wide Meetings from 2008-2012. With a change in her position at the science center just before Site Visit 1, and her eventual departure from the museum just before Site Visit 2, various other education staff members started attending NISE Net events including Network Wide and regional meetings.

A noticeable difference in LPSC's NISE Net involvement was apparent between Site Visit 1 and Site Visit 2; fewer nano offerings and less NISE Net influence was observed in 2014 compared to 2012, although the science center was maintaining its nano partnerships with researchers.

A.3.2.6 City Museum & Science Center (CMSC)

General overview

CMSC is a medium-sized science center in a medium-sized city (population about 200,000), home to several science and technology industries and research-focused universities. In addition to being a science-oriented community, the city has diverse demographics including urban, suburban, and rural populations nearby. Overall, the museum was composed of a large complex of buildings including an on-site school. There also was an off-site nature center associated with this museum. Approximately 60 full-time staff members worked at the science

center including about eight full-time staff in the Education Department. CMSC had a long history of offering hands-on, inquiry-based STEM experiences and exhibits focused on local history that incorporated items from their large collection of regional artifacts. Recent changes at CMSC at the time of Site Visit 2 included the creation of a new exhibit space focused on engineering design, greater emphasis on non-fee based public programming, the development of new events for adults, and the restructuring of the Education Department.

Mission

CMSC's overarching mission was strongly related to STEM education. The STEM focus at CMSC had grown in the last 15 years, in part, due to the arrival of their current president. Along with teaching the public and students about STEM topics, a secondary focus of CMSC was conveying information about the history and natural history of the region. Another aspect of their mission was supporting the community's needs and acting as a community gathering place. The museum had been involved with other national networks such as Portal to the Public and often worked with other large science centers.

Nature of NISE Net involvement

CMSC has hosted NanoDays events every year since 2009. They received a mini-grant to create a nano-themed summer camp and to integrate nano into its gallery programs. They were awarded a *Nano* exhibition which arrived shortly before Site Visit 2. CMSC also had several strong nano partnerships with local scientists and industry partners. These nano partnerships started around NanoDays events and recently expanded to involve summer camp programs. Several staff members had been involved in NISE Net activities and had attended regional and Network-Wide Meetings, the Nano & Society Workshop, and a workshop and webinar about inclusive audiences. A few of the staff members who had been involved in nano efforts had left the museum, although the main NISE Net contact at CMSC had stayed consistent for the last few years.

On Site Visit 2, CMSC was implementing more nano in their programs than in previous years. These additions were seen in their added summer camp offerings, new floor demonstrations, and the arrival of the *Nano* exhibition. Together these efforts seemed to have encouraged more staff awareness of NISE Net and nano, and increased the museum's nano offerings compared to Site Visit 1.

A.3.3 SUMMARY

In this chapter, we provided background information about the Network Core Partners and each of the museums in our study. It is the interaction between the Network Core Partners and the partner museums that constitutes the core of our analysis of organizational change. Although each of the six museums we studied shared some characteristics—for instance, the general mission for all of them was to engage their audiences in fun, interactive science experiences as a way to improve the public's interest in and understanding of science—each museum also had a distinct set of things it wanted to accomplish and resources to work with. The distinct nature of each setting as a community of practice—its joint enterprise, mutual

engagement, and shared repertoire—allowed us to understand broader conditions that can facilitate or hinder organizational change. Although we elaborate on the descriptions provided here as we discuss particular kinds of change in the findings, these overviews provide important information for understanding the rest of the report.

PART B: TWO ESSENTIAL CONDITIONS FOR ORGANIZATIONAL CHANGE: SHARED GOALS AND THE SPREAD OF INFORMATION

Part B examines two essential conditions related to organizational change that emerged from our analysis: shared goals and the spread and application of new information into practice. For NISE Net to promote change in its partner museums, it was critical, that by participating in the Network, museums were able to accomplish their own goals as they simultaneously helped NISE Net achieve its aims. Whereas shared goals provided the motivation for staff members at partner museums to participate in NISE Net activities, organizational change necessitated that the information learned in these activities spread beyond the few individual staff members who were highly involved in NISE Net. In Chapter 4, we provide examples of the alignment or misalignment of goals, and, in Chapter 5, we explore the conditions that facilitated or hindered how information was shared from NISE Net and within individual study sites. Shared goals and the flow of information are key framing concepts for understanding the types of change reported in Part C.

CHAPTER 4. THE IMPORTANCE OF SHARED GOALS FOR ORGANIZATIONAL CHANGE

A joint enterprise, or shared goal, is central to a community of practice. It is the force that brings people together and energizes them to act and carry out mutual engagement (Wenger, 1998a). In our study, we asked staff members at the six sites to tell us about the goals of their museum, their own goals for the work they do, and what they thought NISE Net's goals were. In each instance, we asked staff members to describe how they thought these goals were being enacted in practice, and the degree to which these various sets of goals—especially those between NISE Net and their museum—were aligned or in conflict. Despite differences reflecting each museum's circumstances, we found broad commonalities among partner museums' goals. Moreover, the flexibility of the goals promoted by the Network Core Partners allowed each of the study museums to meet its own goals by participating in NISE Net. In most cases, NISE Net fit well with what museums were already doing, and the Network's primary contribution to organizational change was to provide another topic for museums to include in their offerings. In this chapter, we discuss the goals of the museums we studied and how their alignment or misalignment with NISE Net's aims—whether real or perceived—influenced the extent to which participation in the NISE Network led to organizational change.

B.4.1 COMMON GOALS FOR PARTICIPATING SITES

B.4.1.1 The museums aimed to support science in schools and communities and to provide inquiry learning experiences for audiences of all ages.

In general, participating museums' missions focused on combining science learning and fun via hands-on interactive exhibits that inspired curiosity in an effort to educate the public. When talking about their work, staff members mentioned that the museums also had an important role in supporting both local and regional school systems. They sometimes emphasized that their museum was located in an economically depressed area with struggling schools and teachers who used traditional instructional techniques and had little science background. Therefore, they aimed to support STEM learning by engaging students in science using fun, inquiry-based methods. For instance, the Outreach & School-focused Science Center (OSSC) aligned its science topics with the state's curriculum standards and created ten "loan kits" containing materials and information about difficult STEM topics that were distributed to teachers in the region. Similarly, an important part of the mission for the Pursuing STEM Science Center (PSSC) was to bridge "the gap between the public and educational institutions." As a Senior Leader told us,

> With science in particular, it's important that people see the end product of it. That's kind of where we see our schools have failed. They teach math and they teach physics and they teach the hard stuff. They haven't done a good job of telling kids why it's important to learn those things. And so what we can do is provide that bridge . . . and kind of show where it's fun. (PSSC#2)

At the Young & Evolving Science Museum (YESM), staff members also reported that science is not emphasized enough in formal education; elementary school teachers don't teach

science because they are not required to do so and are often uncomfortable with the subject matter. Because of this, many staff members said that it was part of the museum's mission to educate school children about science and to educate teachers about methods for teaching science, such as using inquiry-based instruction. A staff member at the Small Town Science Center (STSC) also emphasized how they

> want [kids] to be a part of that learning process. . . . to realize that science isn't over. . . . We need to train people to think. We need them to ask the difficult questions and we need them to be excited about being challenged enough to try to find an answer, because we don't know it all. (STSC#5)

Another important goal across multiple sites involved making science content available and affordable for residents of their surrounding areas. To support those who cannot afford admission fees, OSSC provided free memberships to families whose children attend Title I schools (i.e., schools with high numbers of children from low-income families). Similarly, STSC held all of their one-day festivals in an area of the museum where admission was not required, offering these events to all visitors regardless of their ability to pay.

Several of the sites we studied were attempting to become more STEM-focused and, in some cases, wanted to be seen as a setting for adults and families rather than a place just for young children. These museums were working to incorporate STEM content into all of their programs, events, and exhibits. For example, one staff member at PSSC talked about redoing their area for young children to include STEM, in part, by adding "children-friendly microscopes" (PSSC#4). Efforts to increase STEM offerings at the City Museum & Science Center (CMSC) meant putting less emphasis on local and natural history, areas they had addressed in the past, and instead focusing more on science topics:

> I know we're definitely going way more toward science and technology than we ever have in the past, so there's been a really big push on science for the past few years because, I mean, we were pretty natural history-based for a while. (CMSC#5)

There was a notable omission from the goals that staff members mentioned: no staff member described a specific desire to interest or engage their visitors in nanoscale science, engineering, and technology. Nevertheless, despite not explicitly having a goal related to educating the public about nano, we found that all of the museums we studied were motivated to join NISE Net and participate in its activities because the Network provided resources and opportunities for them to meet their own goals.

B.4.2 ALIGNMENT BETWEEN NISE NET'S AND PARTNER MUSEUMS' GOALS

B.4.2.1 NISE Net offered STEM content that helped museums accomplish their missions.

When asked about the relation between NISE Net and their museums' mission and goals, staff members most frequently mentioned shared interests in STEM content and similar methods of conveying information to the public. Many staff members said that their museum's mission to educate the public about science fit perfectly with NISE Net because nano is a science topic that added to their existing STEM content. For instance, when asked how NISE Net aligned with her museum's mission, a Senior Leader noted,

Obviously, ours is a broader STEM mission, so we go further than just nanotechnology, but as far as getting the public to understand science, technology, engineering, and math, and specifics like nanotechnology, that's exactly what we're trying to do . . . through hands-on experiences. (PSSC#2)

The Network's free resources, including materials and activities, also played an important part supporting museums in accomplishing their missions. Like many staff members at other study sites, one individual at the Local Partners Science Center (LPSC) stated that NISE Net's activities helped their organization more easily achieve their goals:

[NISE Net helped us accomplish our mission] through providing us the resources, like material-wise, and also just knowing that we can go to the website, to the catalog, and find a program that's there, modify it to make it our own. So, it allows us to get that information out [to our visitors] a lot easier. (LPSC#5)

Case example: PSSC's rebranding and use of NISE Net materials to help realize this goal

Staff members at several of the museums told us of efforts to become more STEM focused. PSSC provides an example of how adopting nano-related products, programs, and other Network resources allowed organizations to meet this goal.

Two years prior to Site Visit 1, PSSC went through a rebranding campaign. A Senior Leader described the reason for the campaign:

We were previously the [former name] and there was a little confusion in the area as to what we were. Were we a children's museum? Were we a science center? What was our mission, what was our goal? So we kind of had this hodge-podge of exhibits that I think kind of represented both sides and didn't really merge well together. So we've refocused that in the last couple of years and we've come forward with the [current name] Science Center. So we've kind of refocused on STEM: science, technology, engineering, and math. (PSSC#2)

Other staff members in the organization referred to the rebranding as more of an "identity change" than a change in mission. One staff member told us,

STEM was a big part of what we did before, it just wasn't as obvious to the public and we weren't as clear and communicating that to the general public. . . . There was I think a bit of a misconception when I first arrived. I heard a lot of people refer to the [museum] as an indoor playground. (PSSC#6)

The staff at PSSC often said that NISE Net helped them move toward their new mission more quickly than they could have otherwise. As a Senior Leader explained: "One of the challenges [of this rebranding] is we want to do this and we want to change, but now we have to develop all this new programming to reflect out new mission" (PSSC#2). NISE Net helped PSSC move its STEM mission "forward faster, [and] further" by providing "packaged ideas that other people have tried and been successful with" (PSSC#6).

By the time of Site Visit 2, PSSC had incorporated nano into almost all of its museum experiences, including summer camps, outreach programs, and multiple places on its exhibit

floor. The free NISE Net products and resources focused around STEM content "provided invaluable support" (PSSC#7). NISE Net's materials helped the museum take steps toward being thoroughly STEM-oriented and do so more quickly than would have been otherwise possible. Therefore, allowing PSSC to achieve the goal of changing from a setting primarily for children to a science center accommodating a wide range of ages.

B.4.2.2 NISE Net provided products and activities that fit with museums' current goals and practices.

Many staff members felt their museums were able to assimilate NISE Net's offerings into their ongoing goals and practices. NISE Net's programs, exhibits, and overall aims often fit into what the study museums were already doing, thus, making it easy for them to incorporate nano into public offerings without requiring large-scale changes. As a staff member at CMSC stated: "[NISE Net] just fit so well with what we were already doing that it just was like a natural fit. It really was" (CMSC#4).

One of the primary goals for museums in this study was to present science information to visitors in a hands-on way. Though nano was a new topic for most museums, they were able to accomplish this goal by incorporate nano content into familiar types of activities. For example, all of the sites had hosted festival-type events similar to NanoDays. When comparing NanoDays with other events they do, a staff member at PSSC said: "NanoDays for us is like a total science focus whereas other events that we have are geared more toward a specific time of year: Holiday Land or Boo Bash for Halloween" (PSSC#4). At OSSC, NanoDays was considered a small festival event but similar to what they might do for their one-day Pi celebration in March. Chapter 6 provides further examples of how nano content was able to be incorporated into typical programming that met the museums' goals.

In some instances, NISE Net's focus on practices beyond nano content, such as encouraging scientist-museum partnerships, also aligned with museums' goals and current work. This was the case at CMSC where the NanoDays event was able to be part of their monthly "Science Saturdays" that involved external community groups and scientist partners. (CMSC#3). Likewise, the next case example highlights how NanoDays events and NISE Net's commitment to partnerships aligned with LPSC's efforts to work with local scientists. Chapter 7 and 8 also describe how shared goals were important for non-nano practices to take root.

The fact that NISE Net's aims and products often fit so well with the museums' current approaches made incorporating nano into their public offerings easy. In explaining the assimilation of NISE Net, one staff member at YESM remarked, "[NISE Net] enhanced what we do rather than changing it" (YESM#4). In these ways, participating in NISE Net helped partner museums achieve their goals without requiring that they first make major changes in their practices.

Case example: LPSC's ongoing partnership work and alignment with NISE Net's goals

LPSC is a site at which the museum's goals aligned with NISE Net's efforts encouraging partnerships. In this case, the value NISE Net placed on scientist-museum partnerships fit especially well with LPSC's focus on creating partnerships with local scientists. The alignment in goals helped nano become even more integrated into LPSC's current and ongoing work with partners.

Even before joining NISE Net, partnerships were central to LPSC's mission. LPSC hoped to interest students in STEM careers by including information about local STEM professionals in their programs and exhibits. The organization also viewed partnerships as a way to inspire local students to learn about STEM research being done in the region. A Senior Leader used phrases such as "partnering is who we are" and "[partnering is] at our core" when describing these initiatives (LPSC#18). One of LPSC's Education Professionals explained that through partnering with local researchers, the museum felt they could accomplish their mission:

> Our goal here is to get kids excited about careers and get them ready. You know, help schools get them ready for the right jobs. So in [our state], as I'm sure in many other states, there's been this mismatch between the skills the kids are coming out with and the jobs that are available, which leads to unemployment. . . . So having these real people [i.e., local scientists] that kids can talk to either through a mentorship relationship or at least get a look at through the posters and the videos or whatever is extremely important to us [because it helps them know about possible jobs to aspire to]. (LPSC#2)

In part, because of this strong goal related to partnerships, LPSC, unlike other sites we studied, already had partnerships around nano content in place prior to participating in NISE Net. For this work, in collaboration with a local university contact, LPSC had developed a nano-themed exhibition in 2007. This work allowed LPSC to meet their goal of showcasing STEM careers and helped the scientist fulfill "broader outreach" grant requirements. Yet with NISE Net's additional support, LPSC added two more nano-related scientist-museum partnerships. The growth of these partnerships reflected alignment between the museum's and NISE Net's goals.

The first of these new partnerships was in conjunction with a NanoDays event, which the Network Core Partners had anticipated would be a context to bring together museums and scientists. As the scientist partner explained: "[NISE Net has] really been the fuel I think for the whole [partnership]. It was the reason why I connected with [the museum] in the first place; it's been the annual reason why [we get together]" (LPSC#15).

The other nano-related partnership facilitated by NISE Net involved a collaborative effort to build a nano-themed exhibit for LPSC. The exhibit, which included content about a local university scientist's research, again helped LPSC realize the goal of highlighting scientific work being done in the region and allowed this scientist partner to achieve grant requirements as well. For this project, the outside researcher and museum staff built off of NISE Net's *Nano* exhibition, which was already installed at LPSC, to focus on detailed information about the scientist's research.

Not only did NanoDays events and the *Nano* exhibition help encourage these partnerships, but NISE Net staff provided useful information about forming and sustaining

collaborations. According to one museum staff member, conversations with NISE Net leaders helped support a productive partnership by introducing her to resources that could help "focus the scientist's thinking" and give her enough background on a topic she was "not an expert in" (LPSC#2).

These examples illustrate how LPSC's goal—to form partnerships with local scientists and inform the public about STEM careers—was a good match with NISE Net's interest in promoting partnerships between museum staff members and scientists. Participation in NISE Net activities, such as NanoDays events, and support from NISE Net leaders, encouraged LPSC staff members to accomplish work that was at the heart of the museum's identity and current practice.

B.4.3 MISALIGNMENT BETWEEN NISE NET'S AND PARTNER MUSEUMS' GOALS

B.4.3.1 NISE Net's goals and the museum's aims sometimes were misaligned because school curriculum did not always included nano, and a couple staff felt the **Nano** exhibition was not interactive enough.

We found very few areas of misalignment between NISE Net and the partner museums' goals and missions. However, one misalignment that occurred at a few sites was due to the fact that nano content was not included in curriculum standards. Because school offerings typically need to match state curriculum and standards, it was sometimes a challenge to interest teachers in nano-based programming for their students. As one staff member at CMSC said,

> [Nano] is not in the curriculum I don't believe, at least right now . . . it's not on the test that the teachers have to teach to . . . And right now schools are—everything we do has to fit the curriculum, or else they don't want—unless you're going to do it for free! If you had nano outreaches for free, then you'd have no problem. (CMSC#9)

Another staff member at CMSC talked about teacher professional development opportunities, saying,

> I don't see a lot of teachers taking a professional development on nanoscience. Because it is so specialized, unless I could tie it to . . . If I could tie it to this is an engineering lesson that you could do. . . . Because it's like teachers would say, "Well, but I don't teach nanoscience." (CMSC#8)

Similarly, staff members at another museum said that teachers were not interested in a school field trip workshop that was offered around nano. Again, this may have been because the teachers did not find nano relevant to their curricula. Moreover, staff members at several sites said that they had a difficult time marketing the subject to educators.

Although it was particular to just two staff members at two different museums, there were also some concerns that the *Nano* exhibition was not interactive enough to fit their missions. One of them said about *Nano*, "there's more kind of learning by reading than learning by doing . . . There isn't a lot of interactive-ness to it" (YESM#5). The other staff member felt that facilitation was needed for visitors to get science content from the interactive elements:

Even when [visitors] do the ferrofluid, they're still not really getting it. You kind of have to explain what's going on—small, smaller, smallest—they look at it, [and an interpreter needs to say:] "it looks like a fluid now, doesn't it? Look at how it looked over here! It's just because it's a different structure." (LPSC#13)

The two examples indicate potential misalignment between what the Network Core Partners were hoping to accomplish and partner museums' missions and goals.

Case example: YESM's change in mission and resulting misalignment with NISE Net's goals and products

Though misalignments between the Network Core Partners' goals and the goals of the study museums were rare, YESM is one site at which differences existed. Between Site Visit 1 and Site Visit 2, YESM's overall mission shifted, which led the museum to see a conflict between its goals and practices and their sense of NISE Net's purpose. One consequence of this shift in mission was that they discontinued using some NISE Net materials.

During Site Visit 1, staff members brought up many reasons why NISE Net aligned with their mission and goals: along with bringing a current and relevant science topic to the public in hands-on ways, they said that NISE Net integrated science and industry and taught visitors something new. Staff members and senior administrators also talked about NISE Net as connecting their museum to a national community and helping them act like and look like a "big city museum" (YESM#1). A few staff members also said that NISE Net helped the organization in some of their weaker areas by adding Spanish labels to their exhibits, by engaging visitors in conversations about societal and ethical implications of science, and by making science interesting and available for everyone.

However, soon after Site Visit 1 there was an important strategic planning meeting of senior staff and members of the museum's Board of Directors to develop a new set of broad, shared goals. At the meeting, they developed goals for each organizational unit of the museum. As a Senior Leader explained,

One of the most important ones, sort of visions, was that we would become the center of curiosity-based learning and it made us all smile . . . A couple of board members really appreciated what that meant and it's a challenge right? Because curiosity, you can't fake curiosity. You can't make somebody be curious, you have to sort of cultivate it. (YESM#1)

Between the two site visits, this organization had become "less about knowing and more about doing" (YESM#4). Curiosity-based learning, which staff members distinguished from inquiry-based learning, led the museum to develop a tinkering space and hire a staff member to develop programming for it. In several interviews, it appeared that the organization had started to adopt this way of engaging visitors, including using fewer activities that they characterized as demonstration-based or information-based, and, instead, engaged visitors in more open-ended experiences in their exhibits and programs.

In interviews during Site Visit 2, staff members were clear that they perceived NISE Net's offerings were not aligned well with the new mission. For instance, there was a marked

shift in how staff members talked about the kits they received for NanoDays events. On Site Visit 1, several staff members had praised the NanoDays kits, saying that they were of high quality and made the education staff comfortable. As a Senior Leader told us,

> To have something arrive that is so thoughtfully put together but also provides all the tools necessary in order to do some really great one-on-one science or demonstration type stuff is invaluable. It allowed us to do something that we couldn't do normally. (YESM#1)

> Yet, on Site Visit 2 YESM staff members were excited about curiosity-based learning and were moving away from what they called "demonstrations." An Education Professional described this new focus:

> Now when we talk about activities, we want a table of people to be able to come together, and we want . . . every person [to] ha[ve] their hands on something doing something. But a lot of our early activities were: people sit up at the table, and there's one tool, and one person could try it and other people could watch. Then we could take turns. So it was really a demonstration. "Let me tell you something cool, let me show it to you," it can be interactive, but it's not really hitting our mark for hands-on learning for all of our guests. (YESM#4)

NISE Net's NanoDays kits were put into the category of "demonstrations," which YESM was now trying to move away from. When describing the NanoDays kit from this perspective, an Education Professional said,

> People are fascinated by the fact that the lab coat won't soak up water. . . . I feel like they're good sparks. [They get people to ask,] "How does that work?!" Which is why we're parking them more in the demonstration world. Because they spark a curiosity. Then I think where we find we diverge a little bit, is then the next step of: How do people get their hands on and try those things? That's where we're having to find our way a little bit. It doesn't come ready made in the package sometimes. (YESM#4)

The shift in approach appeared to connect to a more general negative view of NISE Net's offerings. When asked how NISE Net fit with the museum's mission and goals in Site Visit 2, a Senior Leader described how NISE Net materials were not seen in as positive a light as before: "I think to be brutally honest is that the amount of newness in the [NISE Net] material is, from my perception, is sort of diminished. The level of newness . . . And approach. I mean everything about it. Everything has sort of diminished" (YESM#1).

As a result of changing perspectives and evolving organizational goals, pursuing nano-related activities had largely dropped off at YESM by Site Visit 2. They did not implement NanoDays in 2014 because, in part due to recent staff turnover, there was little interest in the topic: "You know, it's like NanoDays, yeah, maybe we should try something [else] out. So this year we probably won't be doing NanoDays" (YESM#1). YESM administrators also decided that the amount of funds they could receive from a second NISE Net mini-grant was too little to justify putting in an application.

The change of mission for YESM led to a change in the museum's alignment with NISE Net. On Site Visit 2, YESM's nano offerings were diminished, they did not host a NanoDays

event in 2014, and the NanoDays kits and *Nano* exhibition were seen as the type of offerings the museum was trying to move away from. Overall, the excitement about tinkering and curiosity-based learning had supplanted nearly all of YESM's staff members' enthusiasm for nano and what NISE Net had to offer. This case example illustrates how the lack of goal alignment among communities of practice can impede organizational change.

B.4.4 SUMMARY

Whether they are made explicit or not, goals are central to communities of practice. They are defined and negotiated by the community's members and provide coherence and energy. When two communities of practice come into contact, there is the potential for change, especially if one—as with the Network's Core Partners—provides resources intended to influence how other professionals and communities do their work. To maximize this influence, NISE Net made it possible for partner museums to be able to work toward accomplishing their own goals through their participation in NISE Net. In this chapter, we provided both positive and negative examples of the importance of shared goals for organizational change.

Many staff members noted that the resources NISE Net provided—programs, materials, and professional development—helped them meet a variety of needs. NISE Net's focus on nano added a new science topic to their exhibits and programs, one that helped them appeal to older children and adults as well as to returning visitors. In this way, although incorporating nano content into their offerings was not mentioned as a goal, partner museums were able to meet their own goals and, at the same time, NISE Net achieved its aim of helping staff members bring nano to the public.

The flexibility of how the Network Core Partners went about accomplishing its mission allowed partner museums to use NISE Net resources for a variety of purposes. Museums were able to incorporate the NISE Net materials into programs and efforts that were already underway. This often took the form of adding nano to festivals or other programs. For LPSC, materials and support from NISE Net helped them to further their already-strong commitment and efforts devoted to partnerships.

The importance of shared goals was apparent in the rare instances in which the Network Core Partners' and partner museums' goals were misaligned. On Site Visit 2, YESM's increased focus on curiosity-based learning and on the associated reinterpretation of NISE Net's offerings as demonstrations rather than as joint activities and open-ended exploration, diminished NISE Net's influence: YESM used their NanoDays kits less frequently, cut their nano programming, and showed less interest overall in both NISE Net and nano. A few staff members at other study sites suggested that nano was not a good topic, primarily because it was not included in the curriculum and standards of local schools.

Overall, instances of misalignment were uncommon. Most of the museums we studied accomplished their goals as they simultaneously met NISE Net's mission to increase public engagement with nano. A Senior Leader at CMSC summed this up when asked if NISE Net's mission fit with her museum's mission; she replied, "By paying attention to your mission, I help get my mission done" (CMSC#12). As was seen, changes in practice that included the

implementation of nano were more likely to occur if goals between NISE Net and the museums were in alignment. Future chapters will continue to reference the importance of shared goals as one of the main facilitating factors for organizational change.

CHAPTER 5. HOW INFORMATION FLOWED TO AND WITHIN THE PARTNER MUSEUMS

Examining how information flowed from NISE Net to and within the partner museums was central to this study of organizational change. Community of practice literature emphasizes that sharing information between two different communities allows for new ideas to influence and take root in organizational practice (Kisiel, 2010; Wenger, 1998a). Sharing information is the work of boundary objects and brokers, and we paid careful attention to both in our interviews and data analysis.

For this study we attempted to understand NISE Net as a community of practice and to grasp what types of information the Network Core Partners sought to convey to partner museums. As described in section A.3.1. "Network Core Partners as a Community of Practice," the Network communicated nano content along with ideas about several non-nano practices. These included information about partnering with scientists, using evaluation to assess offerings, and engaging visitors in discussions about societal and ethical implications of science and technology. Moreover, NISE Net provided methods for engaging visitors and other museum staff, strategies which could be applied to various topics beyond nano. The Network conveyed these ideas through physical products (boundary objects) and professional development experiences that key individuals who interacted with NISE Net (brokers) could take part in.

Unlike studies of professional development programs, which typically focus on what participants learned, our study on organizational change led us to examine how information might spread from the highly engaged brokers or various NISE Net products to other staff members within the organizations. For change to occur at the organizational level, it is not enough for museum staff members to return from professional development sessions or to use NISE Net products and then to keep the new ideas to themselves. Opportunities to share and implement what has been learned from these gatherings and materials are critical for widespread change.

This chapter has two parts. In the first, we examine mechanisms for transferring information from NISE Net to the partner museums. This entails crossing boundaries between two communities of practice and includes a discussion about varied broker structures (single, paired, and shifting) and also about the primary boundary objects NISE Net made available to the museums (NanoDays events with their kit materials and the *Nano* exhibition). In the second, we present processes for sharing information within the organizations (formal, informal). Running throughout the chapter is an exploration of how varied structures and processes facilitated or hindered organizational change.

B.5.1 HOW INFORMATION FLOWED FROM NISE NET TO THE SIX SITES

Ideas from NISE Net were embedded in and shared through boundary objects produced by the Network Core Partners, such as NanoDays kits, the *Nano* exhibition, and the Nano Bite digital newsletter. They also were presented in professional development opportunities including in-person meetings, workshops, and webinars. Brokers, the key individuals within an organization who had direct involvement with NISE Net, had the opportunity to participate in

these gatherings, to have conversations with Regional Hub Leaders and other NISE Net leaders, and to use activities that contained the various messages from the Network Core Partners. The next section explores how brokers and boundary objects helped Network Core Partners share information with partner museums.

B.5.1.1 Key individuals played vital roles in sharing information about NISE Net within their museum, although they functioned differently at each site.

Brokers, or individuals who move between two communities of practice, were fostered by the Network in a variety of ways. For instance, NISE Net encouraged museum staff members to interact with the Network by covering their costs and expenses to attend professional development gatherings and encouraging them to reach out to Regional Hub Leaders with questions about nano content and about programmatic ideas. Moreover, the Network often contacted these individuals to promote other opportunities, such as applications for mini-grants. These individuals, who interacted directly with the Network, had opportunities to gain knowledge about NISE Net, nano, and related content and practices. Typically brokers were educators who either headed museum departments or worked with others to develop public programs or to train floor staff. As such, their roles allowed them to share information with other members of their communities. Our interviews with staff members at the six study sites indicate three categories of brokers: solo individuals, pairs of professionals who worked together to implement nano, and multiple people who had direct interaction with the Network over time but for shorter intervals.

Overall, our results suggest that the three types of brokers can all be effective at sharing information across an organization. Frequently, these individuals passed along information about useful NISE Net products or practices and nano-related activities that were occurring on-site. Nonetheless, each of the three broker structures had obstacles related to sharing and implementing information. Examples of the different broker situations are described below along with factors that affected the extent to which brokers were able to spread ideas from NISE Net to other staff members.

Solo brokers

At several of the sites, a single staff member was the broker. All NISE Net-related information flowed through this person, the only staff member from the organization to cross into the NISE Net community. Typically, this solo broker was the one staff member to attend NISE Net professional development meetings and the only person at the organization to receive NISE Net emails concerning upcoming events and opportunities. Other staff members usually heard about nano or NISE Net from this individual who would often spread information about the content or the use of NISE Net products through meetings, casual conversations, and through collaborative work. At the Local Partners Science Center (LPSC) one staff member emphasized the broker's personal enthusiasm and recounted how "she's gone to the conference and she's gone to NanoDays. I guess she goes every time. But she always is very excited about the stuff that's there. It sounds really cool, lots of fun" (LPSC#1).

However, an organization with a solo broker may be susceptible to knowledge loss because of staff transitions. This was the case at LPSC on Site Visit 1. After the main NISE Net individual had switched roles, the next person tasked with doing nano-related work talked about being unaware of some of the history of working with NISE Net: "I don't know much about [NanoDays events] other than we also got a bunch of kits from you" (LPSC#13). Moreover, he talked about how when the previous broker shifted from education to visitor experience there was "a disconnect there for me to talk to [her] about [NISE Net]" (LPSC#13).

Pairs of brokers

In some cases, two staff members from a museum crossed into the NISE Net community and then worked closely with each other to implement nano activities at their organization. This was encouraged by the Network Core Partners, especially in the Network's later years, by inviting two (and occasionally more) individuals from an organization to attend gatherings. At several sites, our results indicate that this broker structure built more stability into nano work, but, on the other hand, could also isolate nano conversations to these specific staff members.

The Pursuing STEM Science Center (PSSC) had a pair of brokers who attended NISE Net gatherings and worked closely to implement nano activities throughout the course of our study. As one explained, it was typical for both to debrief each other after NISE Net meetings and strategize on what they learned and might put to use. They then worked together throughout the year on both nano and non-nano educational programming.

However, both brokers told us that unless they were getting ready to implement a program, they did not share information from NISE Net with other staff members. One broker felt that "[we] are probably the main keepers of that information and I'm not saying that that's good or bad. That's probably how it just comes out" (PSSC#4). Other staff members also recognized that because the two brokers worked so closely together, little information related to NISE Net was shared more widely.

Various brokers over time

At a couple sites the broker role, whether it was solo or paired, had switched between multiple people. In these instances, various individuals had gone to NISE Net meetings and were involved in nano work at their organization. This interaction allowed many people to become familiar with nano and NISE Net but because the broker position shifted among staff, information flow between the Network Core Partners and the museum was sometimes disrupted and not as widely shared within the organization as may have been thought.

The City Museum & Science Center (CMSC) is an example of a site at which different people had been directly involved in NISE Net over time. When describing their initial work, two staff members recalled being active with the first set of NanoDays kits. Over several years, the role of broker shifted to at least three other staff members. During Site Visit 1, when reflecting on the departure of the most recent broker, one staff member described how this individual had "put more thought and time into [NISE Net] than we've been able to do in the past. We're trying to make sure we continue that even without him here" (CMSC#3). Another

staff member commented that the transfer of information was not as smooth as it could have been because the highly involved individual "didn't really have a chance to kind of debrief everybody on what he was doing as far as working with [NISE Net]" (CMSC#2). For example, although the next NISE Net broker at CMSC was eventually given a list of all the previous NanoDays event volunteer contacts, there were delayed transitions between NISE Net brokers.

While having various staff over time who had been NISE Net brokers might theoretically lead to increased spread of information about nano, we found that, especially during Site Visit 1 at CMSC, it was rare to see collaboration concerning nano work. In general, staff members who had previously been involved in NISE Net did not continue to interact with the new brokers concerning nano. This was due, in part, to staff members changing job responsibilities and needing to focus on other areas. As a previous broker told us:

> I don't use [ideas from NISE Net] much anymore. My job changed so much. I haven't really done anything with NISE Net for two, three years, so . . . I know [the NanoDays kits] exist, so, you know, so I pull them out and things like that, but I haven't actually used them for much. (CMSC#5)

Furthermore, during Site Visit 1, we learned it was typical for individual staff members to work independently on tasks. One staff member explained, "One of the things . . . that we practice here is ownership. So we will take ownership of things, whether that be a marketing piece, or a weekend program . . . So, if I have ownership of NanoDays, I am primary from end to end" (CMSC#1). Thus, even though several members of the staff had had connections to NISE Net prior to Site Visit 1, only a few were actively involved in implementing ideas from the Network.

B.5.1.2 Staff transitions and job responsibilities affected how widely key individuals were able to share information.

In all three types of broker structures, data indicated that the spread of information from the Network to the organizations was often hindered by similar factors. In order for ideas to spread from one community to another, it was crucial that when staff transitions occurred they were smooth and that the broker be in a position to share knowledge with other staff. These were two critical aspects for the wide-spread sharing of information whether or not the broker was in sole communication with the Network, had a partner, or even worked within the same organization as other individuals who would have been familiar with NISE Net. Examples of how these barriers affected communication are described below.

Staff transitions

Staff changes played a key role in determining whether or not information flow from the Network to the museums remained consistent, especially if new NISE Net knowledge and practices had not yet been institutionalized before turnover or job changes occurred. No matter the category of broker, staff transitions often meant communication about nano was less frequent.

As the case of CMSC suggests, sites with shifting brokers tended to have more people who knew about NISE Net. However, the potential for information flow related to NISE Net decreased when former brokers had not passed along knowledge or did not continue to implement NISE Net products and information due to new job responsibilities.

At organizations with solo brokers, it was evident that changes in position or the departure of staff could also have a major impact on the organization's knowledge about nano and NISE Net. As seen above in the solo broker section, after the main NISE Net individual at LPSC switched roles, the new NISE Net contact person was unaware of much of the organization's history with NISE Net. In particular, this new staff member described how information about collaborating with the community scientist partners had not been explained in detail. In talking about their nano partnerships with a local university, he said "[I] don't know exactly what they did but [the partner was], from what I understood, very involved in the NanoDays program. They came up with something in conjunction, but that was prior to me" (LPSC#13).

Moreover, when key staff left and nano programs sometimes ended, fewer people at the organization were either formally or informally exposed to this work. At the Young & Evolving Science Museum (YESM), one staff member felt because she hadn't been on staff when the museum was "on boarding" NISE Net,

> I was not here to catch the spark, and I'm sort of the person who then sends out the programming into our organization. I feel like [nano is] something that's going to drop by the wayside . . . The information passing happened to an extent, but the spark didn't get passed. (YESM#4)

As this staff member articulated, in addition to information, effective brokers need enthusiasm— "the spark"—to sustain old ways of doing things and adopt new practices. Coming to NISE Net late in its existence at that site—and not having participated in Network gatherings and other events—this individual had acquired information about nano and what the Network hoped to achieve, but lacked the enthusiasm required for implementing these changes.

Thus, transitions, which were common at all the sites we studied, adversely affected the spread of information related to nano and NISE Net. These transitions slowed the transfer of knowledge from the Network and, at times, impacted the level of enthusiasm for implementing nano with visitors.

Job responsibilities

In addition to the impact caused by staffing changes, the specific role and responsibilities of a broker influenced the institutionalization of information within an organization. Across sites we saw that the most effective brokers were in positions that involved them in training and interacting with other staff members or in positions developing and implementing new programs, exhibits, and content. Moreover, organizational change was more likely to occur when the responsibilities of these brokers included setting policy they could formally embed new ideas into their organization's work by, for instance, reifying them as practices and educational products for use by other staff members.

For example, the initial solo broker at LPSC was able to spread information from the Network Core Partners to many staff members due to her role as someone who worked with education and guest services. Because her job responsibilities encompassed two areas, she was able to implement nano in programs both on the museum floor and for school groups. After she left the organization, no one took on the same responsibilities, and the two departments' work became more distinct. Nano content was only incorporated into school programs, and one staff member described how knowledge was lost: "I know that a lot of people say we used to do certain things and I don't know why we don't anymore. It seems like something kind of fell through" (LPSC#16). The loss of the highly involved individual, who had her hands in two departments, lessened the spread of nano information.

While a broker's specific role and responsibilities could greatly enhance the spread of information from the Network, at times, these job aspects could also constrain what was shared across an organization. In the case of the pair of brokers at PSSC, it was typical for the two of them, as the main program developers, to interact with each other but only to share information with other staff when needed. While it was natural for them to interact in this way, a third staff member described how staff members' roles impacted the level of communication:

> I know [they] are kind of our NISE Net people and they have the focus on it. I don't know if I've really picked up on much of it. . . . I would think that developing these exhibits is what comes out of [attending NISE Net gatherings], but they don't really tell us when they're going even. (PSSC#9)

There were also instances of brokers who felt their job responsibilities limited them as to how much they could implement or share with others. As one individual responded, "I'm in a position that can't institute the changes, I can only relay them because I'm not the director of the department" (LPSC#13). At CMSC, even with the role of broker shifting between several people, as was discussed above, conversations about nano were limited. This was because after switching jobs, the former brokers' responsibilities often no longer included nano, and it was common for individual staff members to work independently. Together these examples suggest how, whether solo, paired, or shifting brokers are involved, the spread of information from the Network is impacted by the opportunities and constraints of an individual's particular role.

B.5.1.3 NISE Net products led to widespread transfer of information from Network Core Partners to many staff members at the museums.

In addition to brokers, the Network Core Partners conveyed ideas and suggestions that partner organizations might choose to adopt through the products NISE Net developed and disseminated. NISE Net's educational products, such as the NanoDays kit or the *Nano* exhibition, presented information about the basic nano content that Network Core Partners felt was most important and appropriate to emphasize in public offerings. This included key facts about the size and properties of materials at the nanoscale and the societal and ethical implications of nanoscale science, engineering, and technology. Moreover, the products conveyed information about methods for implementing universally designed or bilingual offerings that the Network felt would be effective for engaging visitors. These boundary objects

were sources of information and the embodiment of NISE Net values for anyone directly or indirectly working with the Network.

Even though some staff had prior knowledge of nano from their education or from the media, most talked about first becoming aware of nano through NISE Net products, such as the NanoDays kits, the *Nano* exhibition, NISE Net's websites, and other NISE Net programs such as mini-grants. Staff members often credited NISE Net materials for their understanding of nano content. For example, one person said she would "double-check [her] science on something" (PSSC#4) on the nisenet.org and whatisnano.org websites. A Senior Leader discovered more about nano from a science show that his museum created using a NISE Net mini-grant:

> I learned a lot of its implications, you know, [for] like weatherproofing. I learned . . . that . . . nanoparticles have a larger surface area . . . and by expanding the surface area it allows a lot of interesting scientific types of things to happen. (YESM#1)

Although at some sites information about nano content or the museum's participation with NISE Net was not known widely outside of the education department or, even beyond the few staff members directly involved, NanoDays kits and the *Nano* exhibition were two of the most influential mechanisms for spreading this knowledge. In the following sections we provide findings about how the NanoDays kits and the exhibition led to the transfer of information among staff members. We also explore whether these changes appear to be long-lasting and widespread.

B.5.1.4 The NanoDays kits were one way that staff gained exposure to nano, but the spread of information depended on the number of staff using the kits.

NanoDays events and their associated kit products were key mechanisms by which information from Network Core Partners flowed to staff members at participating museums. Several staff members from different sites said that their first exposure to NISE Net and nano was through NanoDays events and the kits provided for use during these celebrations. However, our data indicate that for NanoDays events and the related kits to have a widespread influence on staff members' knowledge of nano and awareness of NISE Net, many staff members needed to use them either by planning, implementing, or facilitating NanoDays.

Provided exposure to nano

At several sites, the NanoDays kits were often used by many different staff members throughout the year and excitement around them was a shared topic of conversation. As one staff member at CMSC explained,

> When we get the kits, or when we get something new, we run up and down the hall saying, "Check this out! You gotta look at this! Let's play with this!" It's like, uh, it's like parents at Christmas time. They're always the first ones to open the toys, right? (CMSC#1)

Comments from staff at all of the museums indicate how staff learned nano content through using the NanoDays kits. The following quote shows how one of the part-time educators

at the Outreach & School-focused Science Center (OSSC) attributed the growth of her increased knowledge about nano—and how to present it to the public—to her work at NanoDays events:

> I worked one [NanoDays event] that we had here and we used the kits. I think I was teaching about the zinc versus sunscreen. And I had one person that was so confused. They thought that if we put the zinc on us we'd have little circles all over us. I was like, "No, no, that's not it." . . . You have to word things differently because [that group of visitors] take everything you say at verbatim . . . explaining that helped me understand it more. (OSSC#9)

At several sites, staff reiterated how the NanoDays kits were resources they could point other staff to for more information about nano. As a Senior Leader from YESM stated, "You know, the books and materials that came in the nano kit were really good because if people go, 'I don't know enough about this!' [I can say] 'Here! Take this book!'"(YESM#1).

Depended on number of staff involved

As a result of widespread staff involvement in NanoDays, many staff members would become familiar with the nature of the event, much of the content presented, and what their museum—and by extension, the Network Core Partners—were hoping to accomplish through it. This was certainly the case at OSSC where NanoDays was run by several staff members and the kits were used by everyone helping out at the event. Because two full-time staff organized the event, several part-time staff facilitated the activities, and other full-time staff members were pulled in when more help was needed, information from NISE Net spread through the NanoDays kits to many individuals. Specifically, part-time staff members worked with their supervisor the week prior to the NanoDays event to learn how to use the kit activities with visitors.

PSSC was another site where multiple staff were involved in facilitating NanoDays events, and, thus, exposed to nano through the kit activities. As one staff member explained,

> All of the staff is on hand when we do our NanoDays, so they might see that even if they don't know NISE Net or our affiliation with them, they've probably seen some kids do some activities or you know, put on some tattoos that kind of stuff. (PSSC#1)

Although some of the museums in our study were able to involve several staff members in their NanoDays events, other sites either were not able or did not opt to have as much staff involvement. In our analysis we found that boundary objects, like the NanoDays kits, may run into barriers for moving information from one community to another when only a few staff members interact with them.

LPSC provided an example of how information flow about nano was hindered when only a few staff took part in NanoDays events or used the related kits. Although LPSC's first NanoDays was in 2008 and had involved many staff members to facilitate NanoDays activities, in recent years NanoDays events were being implemented off-site at the community's annual Science Festival. NanoDays events at the Science Festival attracted many more people than the museum-based version ever did. The new format primarily involved one of LPSC's scientist partners from the local university and his students using NISE Net materials. Because of these

changes the only individual connected with the museum was one member of the Education department, who coordinated the logistics but was not involved with the nano activities.

As a result, many staff members at LPSC were unaware of the museum's involvement in NanoDays events and the museum's connection with the university researcher or NISE Net. For example, one staff member who was not at LPSC during Site Visit 1 had heard of NanoDays events in relation to the university, but did not know about the museum's involvement. During Site Visit 2, even staff who had been previously involved, said that it was really now run by the university.

At museums that could and wanted to involve many staff members in the use of the NISE Net kit materials through events such as NanoDays, there was widespread and potentially long-lasting change in staff members' knowledge of nano and NISE Net. Having more staff involved in NISE Net offerings made the museum less likely to lose nano knowledge with the passage of time and staff turnover. The sites that were unable or disinclined to have many staff involved provided insight into how the spread of information can be hindered when only a few staff come in contact with NISE Net's boundary objects.

B.5.1.5 There was broad organizational awareness of the Nano exhibition due to specific trainings, the exhibition's visibility, and floor-related job responsibilities.

The *Nano* exhibition helped to spread information about NISE Net and nano to numerous museum staff members. Even staff who were uninvolved with nano or NISE Net would mention their knowledge of the exhibition's activities and content. Often staff explained that they first became aware of nano or NISE Net because of the *Nano* exhibition and that this occurred by email, through a staff meeting or training session, or by exploring it on their own for fun or in preparation for work. Our data suggest that regardless of the method used to introduce *Nano,* at sites which were awarded the exhibition nano content and information about the Network transferred to multiple staff members.

Specific trainings spread information

Of the five sites in the study that had the *Nano* exhibition by the time of Site Visit 2, three museums held related trainings. At some organizations, these trainings included the floor staff who would facilitate the exhibition, and at others almost all staff were invited. At CMSC, volunteers and floor staff got an overview of the *Nano* exhibition that encouraged these individuals to "look with those visitor perspectives," thinking about "What's exciting? What would you like to learn more about?" (CMSC#13). Similarly at YESM, information about content presented in the exhibition, including some of the examples of societal and ethical implications of nano, spread through a floor staff training. In this case, to familiarize staff with how to engage visitors in conversations related to societal and ethical implications, the volunteers walked through the exhibit and did an exercise at the tippy table component. As one staff member described it,

> [The staff member facilitating the training] went through . . . not only the exhibits but some of the activities with the cards and she talked about, you know, the tippy table and

all the things and how it was, how what people valued was affected, could affect the decisions, you know, the choices they make in science and the exploration in science. (YESM#11)

Unlike trainings at these sites that focused primarily on people whose roles related to education or visitor services, the *Nano* exhibition training at LPSC was offered to all staff and volunteers. About 50 people attended including staff from marketing, finance, education, guest experience, as well as senior managers from multiple departments. According to the Education Professional who ran the training, LPSC does similar trainings for all new exhibitions, but this one had a particularly good turnout. It allowed all staff to get "the same type of training," and helped the "staff to have a comfort level in knowing what nanotechnology is and how it applies to everyday life" (LPSC#2). A Human Resources Professional said, "the reason I became familiar with [NISE Net] is because . . . I attended the staff training on the nano exhibit" (LPSC#6). This exhibit training which took place before Site Visit 1 was a primary reason that so many people at LPSC were aware of nano and the Network.

When commenting on the exhibition during Site Visit 2, repeat interviewees at LPSC often referred to how they gained information at this earlier training that they still used. On Site Visit 2, an Education Professional was hoping to "do a refresher training for the exhibit" (LPSC#2), which would give newer staff the opportunity to learn about NISE Net and nano content. Indeed, our data show that new staff at this site had less awareness of NISE Net and less understanding of how the Network had influenced the museum than staff interviewed on Site Visit 1. This difference seemed to be because no other *Nano* exhibition training had been scheduled. Data from this site help show how more widespread and long-lasting change can occur when many staff from different departments receive exhibition training.

Visibility engaged wide segments of staff

Yet even in the cases, where no facilitated staff training had ever occurred, the *Nano* exhibition acted as a boundary object that led to the flow of information about nano content and NISE Net. Many staff members explored the exhibition on their own and cited it when asked about their understanding or familiarity with NISE Net. At the Small Town Science Center (STSC), one person said he just "went through it and read everything and looked at it" when the exhibition arrived (STSC#1). Another staff member at STSC learned about nano applications in consumer products through the *Nano* exhibition and commented, "Well that's where a lot of my knowledge of, of silver, nanosilver—they were giving examples of the socks they sell to diabetics and so forth" (STSC#7).

The fact that the exhibition was out on the floor and available for other staff to see certainly helped facilitate the spread of information from NISE Net to multiple staff at an organization. Staff in marketing, exhibits, education, and even at the executive level who usually did not attend trainings also learned about nano and NISE Net through the exhibition because it was typical for everyone to visit new exhibits. As one staff member from CMSC mentioned, "I didn't actually know a lot about nanotechnology, so when I went to the exhibit, I spent some time in there, and I learned a lot that I had no idea there was so much to nanotechnology"

(CMSC#8). A second staff member from CMSC explained how even their Boards had a better sense of NISE Net due to the exhibit:

> I really think once the exhibit came, once they saw what it was about. I didn't do a presentation myself, but I wrote one for the Board of Trustees and the Board of Directors to just give a little blip of what it is. And I think they were really taken aback by it and the fact that it really does stand by our mission. (CMSC#2)

Floor-related job responsibilities made many knowledgeable

For those staff whose positions required familiarity of all the museum's exhibits, the *Nano* exhibition itself insured the spread of this content knowledge. At OSSC, this was the case for part-time staff who were responsible for facilitating visitor experiences at all exhibits. Although these staff didn't go through a formal staff training at which a staff member brought them through the exhibition, they spent a lot of time getting to know the exhibit and its content in other ways. As one staff member told us, "we need to do it on our own, go through [the exhibition] and learn it" (OSSC#3). He talked about spending time with the exhibit on the day it arrived:

> So we ended up getting the nano [exhibition] up like two days early or something like that. And everyone was so excited, like "Wow! Wow! Wow!" So we all sat down and messed with it for almost 6 hours, all of us! [laughs] We all messed with it. (OSSC#3)

A few staff at CMSC explained that they were responsible for talking to the press about the museum. This specific responsibility meant that they needed to become familiar with the *Nano* exhibition and be comfortable talking about it: "We have to know at least enough about [the exhibition] where if we got interviewed by the media, we would be able to answer their questions. So a good amount of us learned about it [because of that]" (CMSC#5).Together these examples indicate that the *Nano* exhibition increased staff awareness of NISE Net and led to a deeper understanding of nano, even if staff members did not attend a formal training.

B.5.2 HOW INFORMATION FLOWED WITHIN THE SIX SITES

Above, we examined how brokers and boundary objects helped the Network Core Partners get information to museum staff members. In this section, our focus shifts to what happens to the information within the partner museums. It provides a detailed look at how information may be shared throughout an organization and what factors facilitate or hinder the spread of knowledge from NISE Net beyond the individual staff members who directly interacted with the Network.

B.5.2.1 Organizational change did not necessarily require all staff to be familiar with NISE Net or nano, especially if they were unlikely to implement the information due to their role.

In this study, we saw a variety of formal and informal mechanisms that helped to spread information about nano and NISE Net within the partner museums. However, it is important to note that organizational change did not necessarily require that all members of the staff had access to information supplied by NISE Net. Staff members at each of the museums we studied

mentioned that some individuals did not need to know about their organization's participation in NISE Net or new nano content.

At some sites, staff members in many departments knew about NISE Net and the museum's inclusion of nano in its offerings. At other sites, that knowledge was limited primarily to members of a single department. When this was the case, other staff members knew very little about NISE Net and the museum's nano offerings, suggesting that they were not included in opportunities to learn about nano because of the assumption that their roles and responsibilities did not require that background. While some organizations offered opportunities for everyone to learn about nano at all-staff trainings, other organizations focused on the spread of information primarily to the people who would most likely implement it. In the example of OSSC, staff members said that only people connected with certain responsibilities would have a way to apply information from NISE Net. As one highly-involved individual said, "Sadly, I don't think any of the other full-time staff really do anything with it [information about NISE Net products and practices]. It's nice for them to hear about it and know what we're doing, but . . ." (OSSC#1). An Human Resources Professional explained that at OSSC although the broker "probably comes back and reports to her staff [after a gathering] . . . that doesn't affect me so she wouldn't debrief me on it" (OSSC#5).

Results from the 2013 Annual Partner Survey sent to active individuals at all of NISE Net's partner organizations, confirmed that information about and from NISE Net may transfer only to people who were most likely to use it. Although 94% of respondents had shared this information with others in their organization in the previous year, it was most common for individuals to do so with staff members in certain types of roles. Information was shared widely with educators (91%) but less so with colleagues in exhibit development (37%), marketing/communications (35%), or administrative/human resources (19%). The survey indicated that 31% of respondents reported sharing information about or from NISE Net with their organization's CEO, President, or Executive Director (Rosino, Cardiel, Beyer, Cohn, & McCarthy, 2014, p. 9).

With a flow of information limited to only staff members believed most likely to use it, other staff were sometimes unaware of resources they may have found helpful. This occurred at several of our sites. At OSSC, for example, the two individuals who were active with NISE Net focused on conveying nano information to the part-time floor staff; as a result this content was only briefly shared with an educator who worked with schools. Instead of one of the brokers passing along information about the nano resources, the school educator had to pursue the nano connection on her own. As she said, "I knew where [the NanoDays kits] were and went in and started digging! I just went in the closet and saw what we had!" (OSSC#15).

B.5.2.2 Both formal and informal mechanisms were used to spread nano information within museums.

Even if some individuals did not necessarily need to be knowledgeable about nano due to their specific responsibilities, the possibility of lasting, organizational change increased when several staff members had broad access to information. When multiple people were able to communicate and implement their ideas, or when new knowledge was institutionalized in

organizational practices, it was more likely to become part of the shared work of the community. It was, therefore, important for our study to understand how information flowed within the sites.

Despite different organizational procedures for sharing, all of the sites we studied utilized both formal and informal mechanisms. In general, formal methods of communication, such as scheduled meetings, shared documents, and email correspondence often conveyed key information to staff members. Informal communication was also common and included casual and spontaneous sharing of information as staff members collaborated to accomplish joint work. Further details about the nature of these formal and informal methods for sharing information are below with an emphasis on how they encouraged or discouraged information from the Network Core Partners to take root in partner museums.

Formal communication

Staff meetings and trainings were two of the most important and frequent formal methods for sharing information among staff members. At the six sites, meetings varied in the number of staff involved and the type of information shared. Sometimes they included a few educators or members of one department, and at other times they included all staff and volunteers. Content ranged from weekly updates and scheduling conversations to larger discussions of museum initiatives such as new branding ideas. Trainings also varied in terms of who attended and what type of instructions and directions were given. At some sites, trainings were limited to people in specific roles and at others everyone from the organization was encouraged to attend.

Meetings provided opportunities to share brief updates with a variety of staff members about current or upcoming nano programming. As one staff member at LPSC explained,

> [Other staff members] usually hear about [NISE Net] from me at a staff meeting where I would just talk about what we're doing, you know, talk about the NanoDays that's upcoming or a conference that's coming up, or this new program, you know, the grant that we got to do the program. (LPSC#5)

Brokers—people actively involved in NISE Net—typically used meetings to provide updates related to the *Nano* exhibition, especially if it was arriving soon. A staff member at CMSC told us, "At our department meeting there was excitement, [with people saying] 'it's opening!'" (CMSC#8). One staff member at YESM recalled that participants presented information about the exhibit at a staff meeting and described how the organization came to be connected with the NISE Network:

> I said the full nomenclature [of what NISE Net stood for] and [my colleague] took over the presentation and told this whole backstory about how we had done a whole lot of work with nano before, and it was no accident that we got selected and it was kind of like there was some homework that got us into this position. (YESM#5)

Like meetings, staff trainings also offered brokers a way to convey the information they received from Network Core Partners to other people in their organizations. In particular, trainings provided more time than was available in a typical staff meeting for individuals to summarize what they had learned through the Network, including some of the practices beyond nano content such as the engagement techniques, which might be useful to others. For example,

various trainings at PSSC provided a way for the two main brokers to share Nano & Society content they gained from NISE Net with other staff and volunteers. As described above, trainings for the *Nano* exhibition also provided an opportunity to introduce people to nano content and messages from NISE Net. Sometimes this was targeted to a specific group of staff who worked on the exhibit floor while in other instances this was open to many different departments.

Taken together, these examples show how brokers used formal means of communication, such as trainings and meetings, to share information they had acquired directly from NISE Net with other staff members in their organizations. Formal communication was also used to introduce staff who were not directly involved with the Network to key boundary objects that had been created by NISE Net.

Informal communication

At many sites, informal conversations among staff members were another way for information about nano to spread. Indeed, several of the staff members we interviewed commented that they were regularly in touch with other employees to confer about the next steps for a project, solve problems as issues arose, or share tips and techniques. These informal conversations happened when staff were working closely on projects, during informal training opportunities, or simply when people crossed paths in the hall or in shared office spaces.

During these casual exchanges among staff members, nano content and NISE Net involvement would sometimes come up. This was especially the case among staff members who were actively working on nano activities. For instance, at OSSC, conversations about NISE Net activities often spread from the brokers to the part-time staff through informal one-off conversations, especially on slow days. A Senior Leader also noted how informal conversations occurred around nano: "I think some of the managers may, you know, say, 'Hey, this is neat, why don't you try this?'" (OSSC#4). A part-time staff member further explained how the floor educators informally work together with some of the nano materials:

There's been times when me and a couple good buddies will come in here and we'll just get all the nano boxes out, and we'll be like, "all right, we're gonna make a new demo." . . . we'll just line 'em up, and we'll test each one and see which one is fun, which one we like, which one kind of fits, which one we haven't done. All sorts of different variables go into it. And we'll just play with them and we'll take them out on the floor, and we'll show guests, and they'll be amazed. (OSSC#7)

At PSSC, both part- and full-time staff members informally approached the brokers to have conversations about NISE Net beyond the meetings and trainings. A staff member explained that these often were in preparation for particular events such as NanoDays:

A lot of [the communication about NISE Net] is through personal communication. We do send out emails and especially gearing up for NanoDays, there were several emails that went out to all of the staff, but we typically—because we're small—we can do that, try to follow up with an in-person conversation to make sure everybody's on the same page. (PSSC#6)

Additionally, brainstorming discussions between PSSC's two brokers on the topic of NISE Net were frequent and informal. One of them reported,

> We go to these meetings. If it's [my colleague] or I or both of us and we come back with our ideas, we share them amongst the two of us, you know, we're usually the ones that make the decisions in the education department, specifically [the colleague], but we're a nice team that way. (PSSC#1)

At CMSC, too, the brokers were recognized by other staff members as the key people who talked about NISE Net. By Site Visit 2, the current broker was described as someone who brought up NISE Net "all the time" (CMSC#14). The broker confirmed this by saying, "I really do talk about nano any opportunity I get." She also explained, "I wear the 'I Heart Nano' button. And people ask me all the time, 'What is that?' It's [a] conversation starter for me" (CMSC#2).

Other informal conversation starters included any of the materials that NISE Net produced for specific Network initiatives. One LPSC staff member described how these materials are shared among the various education staff:

> I know stuff that has been physically mailed to [the broker] has done the desk hop. So when she's done with it, it moves on to the next person, and the next person, until it gets around the office. Everything else is just water cooler talk around what's going on. Like I don't receive many emails about [NISE Net], we don't have meetings about it. (LPSC#17)

Informal conversations related to the NISE Net's mini-grant program seemed to come up spontaneously at CMSC. One staff member described that at first people spread information about these opportunities through "word of mouth. Occasionally people [were] talking about it. Occasionally it will come up at a staff meeting or department meeting, but mostly through chatter" (CMSC#14).

These examples all point to how informal communication between brokers and other staff members was another way that information about nano and NISE Net spread within a museum.

B.5.2.3 Additional factors affected the spread of information including an organization's internal structure, time constraints, and a lack of systematic reporting especially on NISE Net gatherings.

Although information from NISE Net was shared in both formal and informal ways, several contextual factors affected the degree to which information flowed widely within an organization. In addition to the contextual factors related to the brokers, such as staff transitions and job responsibilities, we found that the internal structure of an organization, time constraints of staff, and lack of a formal communication system pertaining to gathering experiences affected how information about nano and involvement in NISE Net was shared.

Internal structure

The museums in this study had a fairly autonomous, and at times isolated, organizational structure. No matter the size of the organization, this set-up often had a negative effect on the spread of information about nano. As the case example below will show, even at STSC—the smallest museum in our sample with fewer than 10 full-time staff members—there was a great deal of specialization in tasks. This division of responsibilities affected who implemented nano.

Likewise, at CMSC, the largest museum in our study with approximately 60 full-time staff members, organizational barriers prevented the widespread sharing of information about nano. During Site Visit 1, CMSC showed compartmentalization both between the museum's departments and even within the education department, which consisted of eight full-time staff members. With respect to sharing information across departments, a staff member at CMSC said, "We are fairly siloed and that has to do with, with workload . . . When you've got a significant amount on your plate, you end up putting those horse-blinders on and not looking at what's outside" (CMSC#3). Indeed, one staff member who had been in the Visitor Services department commented that she knew nothing about NISE Net before she started working in Education.

Even members of the Education Department at CMSC on Site Visit 1 sometimes said they had little understanding of what others were working on in regards to nano. At times, this was due to the department's set-up with everyone having a different work schedule. For instance, staff members who worked Monday - Friday were less familiar with nano because they did not see nano events and programming occurring on weekends. The fact that the administration encouraged staff members to take sole control or "ownership" of their own projects, just as the much smaller STSC did, also impeded information flow between colleagues (CMSC#1). And, as described in sections B.5.1.1 and B.5.1.2 about brokers, even though multiple people in this sizable Education Department had NISE Net experience, when the jobs of key NISE Net contacts shifted, information flow about NISE Net was limited because the internal structure of the organization, at times, discouraged collaboration. This division of tasks and the set-up of the department meant that nano knowledge stayed with just a few people at CMSC.

If the internal structure of a museum meant that only certain people worked on tasks, then information flow about NISE Net was sometimes hindered. We also heard this at PSSC when some staff talked about not being aware of new ideas that had been presented at Network gatherings. As a staff member explained, information about gatherings "really doesn't funnel through us [because] we're not directly related with the program or the teaching or the educational side of it" (PSSC#5).

Time constraints

Time limitations were another main reason why information from NISE Net sometimes was not shared widely. Brokers did not always have enough time to share information formally about their NISE Net experiences and other staff mentioned not having time to learn from or work with their colleagues.

In particular, many staff members who had attended NISE Net gatherings said that they wanted to share ideas with their colleagues when they returned, but that the allotted time to do so

was often filled with other pressing work. During formal meetings, more immediate needs and updates took precedence and there were few opportunities for staff members returning from a NISE Net gathering to talk about what they had learned and how it could be applied to their work. As one staff member from YESM said,

> When [the attendees] come back, they usually give a report of what they saw at our staff meetings. So it's pretty brief, less than five minutes, and then if we want more information we can go and ask them about it. (YESM#3)

A different staff member from YESM recalled how once after attending a NISE Net gathering a colleague

> gave us a 10-minute blurb on it. Didn't really talk specifically about what they did, but just that it was wonderful and they had all of these things and this big box of stuff was going to come down and they could do everything that they did. (YESM#10)

Staff at both small and larger organizations noted having limited time to learn from each other. One staff member from PSSC explained that little information from NISE Net gatherings had spread through her organization due to rushing with other work:

> Partly . . . because there's so few of us and we've just been constantly like "Go, go, go." I think that's probably a big part of it. We just haven't had the chance. I mean sometimes they'll kind of fill in a little bit, but we haven't really gotten any in-depth stuff from them. (PSSC#8)

Time pressures at CMSC made it difficult for staff members to convince others to allow them to implement improvisation exercises. One staff member said,

> I will say honestly the time is a super constraint for us. But that's one of the bigger pieces that we really feel would be a huge asset to a museum [it would help] having all the departments involved . . . [but] allowing the staff to have the time to participate in those things as well as me being able to coordinate it [is difficult]. (CMSC#2)

As will be seen in the next case example, time constraints held one individual back from observing NanoDays kit use at STSC. Likewise, a different staff member from STSC mentioned,

> Even though we're a small staff and we work in a small building and we cross paths, we don't always have time to talk to each other. . . . We're passing in, you know, kind of in the night sometimes, and everybody's on their own projects and doing their own things. So unless, you know, there's a little bit of downtime once in a while we'll sit and chat with each other about who's doing what. (STSC#5)

Lack of systematic reporting on NISE Net gatherings

Although time constraints and individuals' particular job responsibilities played into whether or not information about NISE Net gatherings was shared widely, the lack of systematic methods for reporting back on meeting experiences also seemed to hinder the spread of information related to NISE Net.

Even though our results indicate that both individual attendees and senior administrators valued the free professional development opportunities that NISE Net made available to staff members from partner museums, it was rare for other employees to learn much about these experiences, including the specific content or practices discussed during them. The information that was shared most frequently came from the Nano & Society Workshops. However, many of the less involved staff did not realize that this content had come from a NISE Net meeting. As section C.7.1 will show, the enthusiasm initially displayed for this content waned with the passage of time. Overall, our data indicate that staff members rarely talked about gaining content information from colleagues who had attended NISE Net gatherings such as Network-Wide or regional meetings.

Staff members at various sites commented that they needed to improve how they could share information after attending NISE Net's professional development gatherings. At CMSC, when asked how they share with other staff what they learned after attending an in-person meeting, one individual reported their current process was not very effective,

> If it's a big meeting [that we attended] we have to do it in our staff meetings. . . . We'll have those once a month. Everybody's supposed to be there, but, you know, it's—that's in the morning, 8:30 in the morning . . . we only have a half an hour. We open at 9 . . . So sometimes our time is very limited in there, and, you know, we try and jam as much in. (CMSC#1)

In reflecting on mechanisms for sharing information after gatherings, a Senior Leader from YESM noted "We probably don't have as good of a formal arrangement on how to do that, but it happens informally." (YESM#1) Likewise, a Senior Leader from LPSC emphasized that they should have a better way to share information regarding outside professional development experiences. He said that even for big conferences like ASTC information is

> not [shared] as systematically as it maybe should be. . . . we did one professional development, one staff thing, and I think it was just full-time staff to give the highlights and so I think people were aware of some of the things that we had seen, learned or heard about, and we could follow up with those individuals that attended if we wanted further information. We're not doing that as systematically as we should. (LPSC#18)

Overall, there was little formal communication about meetings. Beyond that, staff members who had not been to gatherings even had a difficult time remembering instances of learning about meetings through informal mechanisms. As a staff member from OSSC explained, "I'm not sure if anyone—or if I've talked to anyone—that's been to a NISE Net meeting. I'm sure [a colleague] or [a different staff member] has [gone], but I can't really recall" (OSSC#7). And it was common for many who were less involved in NISE Net to say they have "basically . . . heard nothing" about these gatherings (LPSC#12). All together the data indicate that communication about NISE Net gatherings, in particular, rarely happened through formal or informal mechanisms.

Although attendees were often enthusiastic about what they learned at these events, without a system to report on these types of experiences, it seemed that information about gatherings was not typically shared widely. The study found that these individuals need time and opportunities to discuss this information at length with others, otherwise, knowledge will not

spread among the staff. Certainly, particular staff were chosen to attend the meetings because the content matched their responsibilities. Yet when information is not shared widely, there is a greater likelihood that the information will remain with just a few staff members, have more limited implementation, and, as a result, be less likely to lead to lasting organizational change.

Case example: STSC's internal communication mechanisms and factors that affected the spread of nano information

An in-depth look at how information spread within STSC offers a view of how nano content was shared through both formal and informal means. Yet this case example also showcases barriers that affected staff members' ability to learn from and work with one another, thus, hindering the flow of information and making it more difficult for nano to become widely embedded within the work of the organization.

Due to its small size, with fewer than 10 full-time staff members, everyone did a little of everything at STSC including developing and delivering programs on- and off-site, engaging visitors on the exhibit floor, and staffing the cash register in the entry. Weekly staff meetings were crucial for sharing information and getting everyone on the same page for the upcoming week of activities. As one staff member said, "Everyone who works here is pretty well aware of exactly what we're doing . . . with anything almost because . . . we are so small, we have a staff meeting every single week" (STSC#4). Even though there was time for staff to give updates about their work, the majority of the meeting was spent looking at the calendar and planning for upcoming weeks. Staff members needed to be aware of which groups were coming in and which programs were coming up so that the correct person could be there to facilitate the programs. As this staff member went on to explain, "If someone wants a raptor program, [a certain individual] has to be here . . . If they want light and sound or newton's principals, [a different person] better be here" (STSC#4).

Meetings were sometimes an opportunity for quick updates about NISE Net and nano. For example, during the initial period when the Network reached out to STSC, staff discussed whether anyone had time to start working with NISE Net and what the Network was. The main individual, or broker, who ultimately became involved in NISE Net described how he was able to provide short updates on what happened at NISE Net gatherings he attended or the mini-grant project he was working on during these meetings. Many staff reported learned about NISE Net, or first hearing of their involvement with NISE Net, at a staff meeting.

Staff also acknowledged that much of the information flow at STSC was conversation-based and informal. At times, information was shared when people worked together to develop or present a program. Four individuals, in particular, appeared to informally check-in with each other about programming. When commenting on how the small staff communicated, one individual explained, you can "holler out and get anyone in this building . . . on the intercom" (STSC#6).

Informal conversations about NISE Net also took place, especially with the broker. This individual was seen as the main hub of NISE Net information flow for the museum. People went

to him if they had any questions about the Network or wanted to talk about his latest nano work. When describing what he knew about NISE Net, one staff member mentioned the broker as

> the one that's involved with it, and he was the one that . . . is currently working on, the nano exhibits . . . for the exhibit floor. And I've talked to him a little bit about . . . what it is, and kind of what we want it to look like and how can we make it more, you know, user friendly and hands-on, and things like that. But beyond that, I have not done any research on my own, so I don't know much other than that. (STSC#5)

Although a variety of communication mechanisms were taking place at STSC, barriers to information flow around nano existed. These reflected the internal structure and time constraints of staff. Even though all staff pitched in and helped with different aspects, due to the small size of STSC, staff members also specialized in particular science topics and handled their own projects. These areas of expertise were based on individuals' experience and interest, for instance, one staff member presented programs on biology, another on the physical sciences. Thus, there were limited opportunities to learn from each other through collaborative work. Several staff members explained that the primary contact with NISE Net focused on the physical sciences, which, they believed, was the area closest to nano. Rather than engaging with nano themselves, they tended to give all information about NISE Net and nano to this individual. Indeed, one staff member told us that although she was the first person to learn about NISE Net after stumbling on its website and then applying for STSC's first NanoDays kit, she gave this project to the physical science colleague because this was not her field: "Since then I've not had a lot to do with it because there's too many things to do and . . . he's better with physical sciences than I am" (STSC#4). The tendency to separate into distinct areas of expertise limited the spread of information about nano and the incorporation of concepts from NISE Net into people's work.

Time pressures at STSC—exacerbated by the small number of staff members—also made it difficult for individuals to learn from one another. Time for collaborating or talking with each other was limited, in part, due to the fact that staff typically handled their own projects and specialized in their own topics. One staff member recalled how these issues hindered her ability to learn about nano from a colleague who had facilitated NanoDays kit activities when he substituted for her preschool class:

> I really would like to find out what he did because I would really like to be able to use that stuff a little more. I'd like to get some kind of a workshop where he has more time. It's hard to get an open block of time where three employees are doing the same thing because we sometimes only have four here at a time and so then almost everybody is busy, so that's really difficult to do. . . . We don't have enough employees to watch the front desk and the exhibit floor and there's lots of timed activities or the Science Club or a birthday party or whatever. So it's hard for us to get time to get everybody together— it'd have to be after hours. (STSC#2)

Moreover, even though updates about NISE Net gatherings sometimes occurred during the weekly staff meeting, there was clearly limited time to do an in-depth debrief about these experiences. All staff at STSC were aware when individuals attended NISE Net gatherings because the absence of one or two staff members was notable and required planning to cover

shifts and programs. Yet some staff members felt like they didn't hear as much as they could have about NISE Net gatherings after staff returned. A Senior Leader explained, "I don't think they did enough. . . . They did to some extent. I fault myself for part of that. I should have seen that it happened more." (STSC#9) Even the broker mentioned that after attending an in-person gathering, he felt there could be better ways to share take-aways with others:

> We've got to do more of that [because we will] have a staff meeting and during that meeting there'll be [only] 15 to 20 minutes where you'll highlight what you do, what you've heard, what you believe in, where you think that's going to take you in the very near future. (STSC#6)

As this case example shows, information about nano and NISE Net flowed through STSC in a variety of ways including staff meetings and casual conversations with the broker. Yet, it also highlights how more sharing of information could have occurred. At times, the museum's structure and division of responsibilities did not allow staff the opportunity to delve into topics that were unrelated to their expertise. Moreover, time was limited and so it was often difficult to learn from others or share extensively about NISE Net experiences. These factors impeded the widespread adoption of nano.

B.5.3 SUMMARY

In order for one community to influence another's work, new ideas and messages need to be able to cross an organization's boundaries and become embedded in its practice. The possibility of change on an organizational level increases when this information flows to numerous staff who are able to implement and use these new concepts in a variety of ways. NISE Net worked to share information with the various partner museums through brokers, or individuals who were highly involved in the Network, and boundary objects, or physical products such as the NanoDays kit and the *Nano* exhibition. In this chapter, we described examples of how these mechanisms worked on an organizational level for transferring information and why they ran into barriers.

Whether as solo individuals, as pairs of professionals who worked together to implement nano, or as multiple people who had direct interaction with the Network over time, brokers spread information about the Network to other staff. This occurred in formal situations, such as trainings or meetings, or informal conversations or joint work. The NanoDays kit materials along with the *Nano* exhibition were also sources of information for many staff members about nano. Staff were often introduced to this topic area and their organization's involvement in the Network by facilitating these activities, attending a related training, or simply exploring the exhibition on their own. In these ways, information from NISE Net was able to cross from the Network to the museums.

Widespread sharing of information, which is crucial for organizational change, was evident at sites where multiple people were involved in implementing NanoDays events, had gone to an exhibition training, or needed to be knowledgeable about nano to perform their job. When nano became a frequent topic of conversation, was readily used by various staff, and was integrated into their programming, information from NISE Net was widely shared. Together,

these factors increased the likelihood that long-lasting organizational change around ideas from NISE Net would occur.

However, the flow of information about nano was disrupted by barriers such as staff transitions or job responsibilities that kept brokers from implementing or sharing their nano knowledge with a range of staff. Moreover, the flow of information at an organizational level was impeded if the internal structure of an organization meant that staff were primarily working on their own or that they didn't have the time to share with others about nano-related ideas. Even if individuals who had gone to NISE Net meetings had gained valuable insights from these experiences, this study found that without a systematic method for sharing this information with other staff, this information was less likely to influence the practices of the larger organization.

Ideas and messages from NISE Net flowed to all six sites, but the degree of sharing among multiple staff varied depending on circumstances. The issues raised in this chapter concerning information flow will be seen as important factors in subsequent chapters. As will be discussed, organizational change that appeared to be long-lasting was integrally tied to widespread flow of information.

PART C: PRIMARY KINDS OF ORGANIZTIONAL CHANGE DUE TO PARTICIPATION IN THE NISE NETWORK AND THE CONDITIONS THAT FACILITATE THEM

Part C presents findings concerning the types of changes that occurred at our sites as a result of participating in NISE Net. We examined three primary areas of change: changes in partner museums' public offerings, such as programs and exhibits (Chapter 6); changes in the museums' practices unrelated to nano content (Chapter 7); and changes in museums' partnerships with local scientists (Chapter 8). In addition to descriptions of the organizational changes that we found, in these chapters we examine factors that facilitated and hindered change and influenced the widespread and long-lasting nature of change, referring to goal alignment, information spread, and other contextual features mentioned earlier in the report.

CHAPTER 6. CHANGES IN STUDY MUSEUMS' PUBLIC NANO OFFERINGS

As a community of practice, NISE Net's source of coherence underlying all of its activities is "fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology" (NISE Net, 2014c, para. 1). NISE Net has employed a wide range of strategies to achieve this goal, including providing professional development for museum staff members, developing and making available (on www.nisenet.org) a multitude of activities for both onsite and outreach programs, providing manuals for reaching new and underserved audiences, and distributing materials—including the *Nano* exhibition, NanoDays kits, and information about delivering programs—that partner museums throughout the Network could use to engage their audiences. In our research, we found that participating in NISE Net led all of the museums we studied to increase their nano-related public offerings. Most of the organizations we studied had no nano content before they joined NISE Net, so any inclusion of nano marks a significant change. Among the various nano-related offerings that the study sites incorporated into their work with the public, the most common efforts focused on exhibits and programs. In this chapter, we explore how participating in the NISE Network led partner museums to increase their nano-related public offerings in these two areas and, thus, as part of the process fostered organizational change. We include reasons as to why some of the changes in public offerings associated with participation in NISE Net had broad, long-term impacts and why others were more limited.

C.6.1 EXHIBITS

Our study indicates that two types of exhibits led to organizational change at the museums: the *Nano* exhibition and nano-related exhibits museums created on their own or in collaboration with scientist partners. Public offerings with respect to nano expanded and, in many cases, other organizational changes such as increased staff knowledge of nano occurred (see Chapter 5). Overall, the introduction of these exhibits often led to long-lasting changes related to public offerings, and reasons for this are described at the end of this section.

C.6.1.1 The **Nano** *exhibition increased the amount of nano presented to the public.*

One of the main ways that NISE Net increased the museums' public nano offerings was by providing the sites with the *Nano* exhibition. Of our sites, five were awarded a copy of *Nano* after applying for the exhibition. The sixth site received the exhibition on loan from a NISE Net partner, even though that was not part of the original agreement with NISE Net. Overall, in terms of timing, two exhibitions arrived before Site Visit 1, three others arrived before Site Visit 2, and one had not yet arrived at the completion of our data collection. Staff members at all museums were enthusiastic about receiving the exhibition and praised its content and design, although a few raised concerns to be discussed below.

Overall, staff members indicated that the *Nano* exhibition was a significant contribution to the inclusion of nano-related content in their museums. Staff members at several of our museums told us that because *Nano* is meant for the public and on permanent display, it would enable them to reach more visitors. One staff member from the Outreach & School-focused

Science Center (OSSC) noted that *Nano* is a nice companion to NanoDays events "so that we have a nano presence all year long" (OSSC#10). A staff member from the Small Town Science Center (STSC) appreciated how *Nano* allowed visitors to come in contact with this content outside of NanoDays celebrations. As this individual explained,

> We knew that we were getting it [the exhibition] around the time of Nano Days, so we would tell people to come back, we're going to have this exhibit and it happens to be in part of what we call the free part of the museum. So when people come in and say, "Can we use your bathroom?" We say "Oh yes, you know, be sure to check out the nano exhibit." Or we challenge people, "Have you built the nano tube yet?" So it's . . . yeah! It's nice to have something in that space and people can see it right when they walk in the front door too. (STSC#8)

A staff member at the Local Partners Science Center (LPSC) also noted that *Nano* would allow them to reach more visitors than their other nano offerings:

> [*Nano*] just gave us another way to deliver the message [about this content] to everyone who walks through the door. I mean everyone—the public, our volunteers—can feel more confident in talking about it. . . . So in that way I think the exhibit just changed [the museum] a lot. It just had an impact on a lot more of our guests whereas before it was just NanoDays or if people were just taking that [nano] workshop . . . with far fewer individuals receiving the message. So it's really the exhibit that was the game changer there. (LPSC#1)

C.6.1.2 Receiving a **Nano** *exhibition led a few museums to develop additional public programs about nano content.*

In addition to increasing museums' exhibit offerings on nanotechnology, NISE Net's *Nano* exhibition led to additional changes in the public offerings of the organizations we studied. In some instances, the exhibition led to new or enhanced programming related to nano content.

Staff members at most, but not all, of the museums we studied described ways that having *Nano* in their galleries either could lead to or already had led to additional public programming. This ranged from opening celebrations to cart demos and other programs with nano elements that complemented the exhibition. Staff at several museums told us that they generally try to link gallery programming with exhibits and made the same attempt with *Nano*. Thus, the exhibition was sometimes a place or back-drop for nano-related information to be presented in other formats. One staff member at OSSC, describing how their part-time staff now take out small nano-related activities and do these on the floor near the exhibition said,

> We have the butterfly, you know what I'm talking about, where you shine the light behind it? Well we do [little] demos, and so we put that into a shoebox, and so we would go around and we'll show kids and talk about it a little bit. (OSSC#8)

Often this was the first time that these museums included any nano content in their on-floor programming and staff members were excited about the possibilities for incorporating the exhibition into other types of work as well. As a staff member at the City Museum & Science Center (CMSC) put it, even before receiving the *Nano* exhibition,

I definitely think it will accomplish having better programming in the sense that, you know, we do use our exhibits in programming. But if we can have a program that's geared around nanoscience and have an exhibit for them to go to and play with, it's totally different than, you know, sticking them at a table and saying, "Imagine and think really, really small things!" (CMSC#2)

Another staff member suggested that the *Nano* exhibition might increase visitors' interest in nano-related programming:

I don't think anyone's necessarily coming because they heard we have a nano exhibit or anything, but I can see it being [that] people being exposed to nanotechnology through the exhibit then are interested in any programming we have that relates to nano, like these public shows or anything else we might have in the future. They'd be more likely to come to and we could possibly then start incorporating nano activities into, like, our public programming on holidays or things like that. (LPSC#1)

In some instances, the *Nano* exhibition was an opportunity to extend learning that was initiated in an existing program. For instance, a staff member at OSSC said that the exhibition supported her efforts to "revamp the education programming to build in things that the teachers can't do in the classroom" (OSSC#15). In particular, the nano and the ferrofluid components of the exhibition connect with the topic of magnets. She was trying to modify laboratory programs, primarily for students on field trips, so that they connect with the exhibits on the floor, and said that *Nano* allowed for this.

Several of the study sites enhanced the *Nano* exhibition with their own additions, perhaps using materials from the NanoDays kits or funds from a mini-grant. For example, staff members at the Pursuing STEM Science Center (PSSC) said that they added their *Nano Space* exhibit designed and built with mini-grant funds to the *Nano* exhibition and then received a second mini-grant to further enhance the *Nano* exhibit and better coordinate it with their own offerings. Staff members at LPSC added components to the exhibition that highlighted their unique focus on nano research at nearby universities as well as on local scientists in the field. At the Young & Evolving Science Museum (YESM), for the exhibition opening, staff incorporated NanoDays kit materials and hosted a special members and employee preview at which nano activities were presented in the space. These examples illustrate how the *Nano* exhibition, at times, increased other nano programming at our sites.

C.6.1.3 Involvement in NISE Net encouraged the development of other nano-related exhibits.

In addition to the role that the *Nano* exhibition played in increasing museums' nano programmatic offerings, participating in NISE Net led some of the museums to develop their own exhibits with nano content. Although these new exhibits came about in a variety of ways, they all led to increased public offerings related to nano. In these instances, NISE Net's support helped expand visitors' exposure to nano.

At LPSC, for example, before the NISE Net exhibition arrived, they already had an exhibit on nano and were in the process of creating an even larger space dedicated to this

content. Because *Nano* covered basic information about the topic, the museum was excited that it could adjust its work and present deeper concepts in its upcoming exhibit:

> Before we got the mini-exhibit, we had this other project going on with the folks at [a local university] for the new nano exhibit and [*Nano*] enabled us not to have to start from scratch with this nano exhibit and say, "Here are the basics of nano and now here is the research that's going on at [our local university]." It really helped us to move that forward and so we were really excited about that and for us to be able to refresh a whole exhibit area all at one time was a really important thing, which we don't usually have an opportunity to do that so quickly. (LPSC#2)

Funds supplied by the NISE Net mini-grant program allowed two other sites to develop nano-related exhibits that would not have been developed otherwise. In the case of STSC, after two staff members attended a regional NISE Net meeting, they were eager to add nano content to their museum and, driving home from the meeting, developed ideas to apply for a NISE Net mini-grant to build a nano-related exhibit:

> The ferro sold for me, I thought it was so cool. . . . and the way that [our exhibit] will operate is that it'll have two buttons. One will run the pump for the fluid around to it and the signboard, there will be two buttons-- one will run the magnet and one will run the pump and it'll be all kinds of different ways in which it'll lead [to interactions]. (STSC#6)

Building off of this work, staff at STSC hoped that eventually they could develop a suite of nano exhibits using materials from a variety of NanoDays kits.

Staff at PSSC also used a mini-grant to develop a new nano-related exhibit. This project, which greatly expanded the amount of nano presented at the museum, is described in more detail in the upcoming case example. Together, these efforts illustrate how study sites were able to leverage resources from NISE Net, including *Nano* and mini-grants, to help create new nano-related exhibits and increase their public engagement in nano activities.

Case example: PSSC's utilization of NISE Net resources to develop nano-related public exhibits

PSSC is an especially good illustration of how study museums used NISE Net resources to develop exhibit areas related to nano that significantly increased their organization's public offerings related to this topic.

During our first site visit, staff at PSSC discussed three primary goals for their audience engagement: (a) to further their rebranding campaign by increasing their STEM content for visitors of all ages, (b) to add exhibits that could be updated frequently as a way of keeping the visitor experience fresh, and (c) to provide more interactive experiences. With these aims in mind, two PSSC staff members developed a proposal for a mini-grant which, once awarded, provided funds to develop a small exhibit, the *Nano Space*. Located in a previously-unused alcove in one of their galleries, the *Nano Space* contained posters, hands-on activities with instructions, other materials taken from several NanoDays kits, and a few newly-purchased items

such as microscopes. PSSC staff members reported that NISE Net's mini-grant program was what made it possible for PSSC to develop the *Nano Space*:

> The mini-grant was influential in setting up our *Nano Space*. . . . You know, a smaller facility like ours, we don't need a lot of money. . . . Where at larger science centers that might be a pittance, but for us that's a pretty major thing that we can accomplish. (PSSC#2)

The *Nano Space* increased PSSC's STEM offerings, incorporated interactive activities from several NanoDays kits, which could be rotated frequently, and led to additional opportunities for the public to engage in nano. Similar to the *Nano* exhibition, PSSC's *Nano Space* was a venue for the delivery of new nano demonstrations and cart activities. It also led staff members to think deeply about how they engage visitors in a variety of areas, such as hands-on and interactive activities and stimulation of the senses:

> I think [the staff has] been trying to do that for a long time here but, maybe didn't know how or just didn't really have a focus for it. So, I think having a specific, the specific *Nano Space* has kind of helped us branch out and think about how we can incorporate those same kinds of things but into our other areas. (PSSC#8)

Staff members also anticipated that nano-related programming developed for and tested at the *Nano Space* eventually would lead to increased nano-related public offerings throughout the museum:

> Long term, we've played around with the demonstrations in the *Nano Space* and long term our cart demonstrations and interpretations and stuff will happen and nano will be incorporated into our regular ones, including the physics and chemistry and that kind of stuff, so nano will be incorporated into that because of the *Nano Space*. (PSSC#1)

Building on the success of the *Nano Space* and the staff's enhanced confidence and skills as a result of developing it, PSSC applied for and received a second mini-grant to support the integration and enhancement of the *Nano Space* with the *Nano* exhibition. The two were placed adjacent to each other, creating a gallery area devoted to nano.

PSSC's use of two small grants from NISE Net had a major impact on the museum in terms of increased nano offerings and of staff reflection on how they engaged the public. The mini-grants and NanoDays kits provided a low-risk opportunity for PSSC to try new ways to engage their visitors with nano—develop their own exhibition; utilize a small, unused area of their gallery; convert NanoDays kit materials designed for facilitated activities into stand-alone components; and present information on a complex scientific topic.

C.6.1.4 Exhibits often led to long term changes in public offerings because they were incorporated into permanent collections, were aligned with organizational goals, and were less vulnerable to programmatic barriers.

For each of the museums we studied, NISE Net participation led to increases in exhibits related to nano; the museums hosted the *Nano* exhibition and, in some cases, used NISE Net resources to also develop their own exhibits. Consequently, NISE Net increased these museums'

ability to engage large segments of their audience with nano content. Moreover, the new nano exhibits represented significant changes that staff members at these organizations expected to have a long-lasting impact.

This section describes several of the reasons why exhibits, in particular, seemed to lead to long-lasting changes in public offerings. For this analysis, we considered a nano offering to be long-lasting if it was incorporated into a museum's practice and sustained over several years. For example, some new nano offerings in use during Site Visit 1 were still in existence during Site Visit 2, and staff members often anticipated that these offerings would continue for years to come. In contrast, short-lived offerings were those which were developed as a result of participation in NISE Net, but, which, by Site Visit 2 had been discontinued or were not expected to last.

Incorporated into permanent collections and on view for long periods of time

The *Nano* exhibition, in particular, appeared to lead to long-term change because it was often incorporated into museums' permanent exhibit collections. This was seen at our museums at which *Nano* had been on the floor for multiple years and was expected to be on display for the foreseeable future, thus, becoming part of the organization's rotating collection. Similarly, other nano-themed exhibits built by partner museums were considered to be lasting additions to exhibit offerings. An example is PSSC's nano-themed exhibition that was created using mini-grant funding prior to Site Visit 1. By Site Visit 2, this exhibition had been further developed and expanded. One staff member, in talking about the lasting impact of the *Nano* exhibition and their own exhibit built with NISE Net funds, commented:

> In the museum, as you heard this morning, our [exhibit built using mini-grant funds] is permanent. It'll change obviously, we'll have to update it as needed, but that is a permanent . . . our mini-exhibition will [also] stay here. That [area containing the two nano-themed exhibits] is a permanent exhibit area, so that will absolutely stay. (PSSC#1)

In general, even though most museums had the goal of frequently updating their offerings to help engage repeat visitors, this was difficult to achieve. Due to budget limitations, most exhibits at these museums did not turn over frequently and were, therefore, likely to be on view for several years. While staff often saw the *Nano* exhibition and mini-grant funding as opportunities to present new exhibits, they also recognized the long-term exposure these offerings could have. One staff member at YESM pointed out that, in the future, his museum could rely on *Nano* because of its design qualities and continually relevant topic.

> We see it as one more horse in our stable that we can easily put out, we can easily move it to a different area. It always looks professional and fresh and becomes part of what people come to expect and if it disappears for a while and . . . then all of a sudden it reappears, [they seem glad and say,] "oh it's back." It does look new. . . . [besides the] impacts of nanotechnology are not going to go away, . . . [this will continue to be] the place to come and here in the region . . . [to] ask the important questions. (YESM#1)

A staff member at another museum also felt the *Nano* exhibition would have lasting effects on their public offerings because it would continue to be on view:

> Well, we'll keep the exhibit and we'll still keep showcasing it. So yeah, I think there'll
> always be a place in our museum for nanoscience because of that exhibit. . . .What will
> probably happen is that it will probably go through a rotation with some of the other
> exhibits that we own, but it will probably be up every year at least for 3-6 months if not
> more. (OSSC#4)

As is evident, the *Nano* exhibition or those built with mini-grant funding were likely to have impacts on public engagement with nano for years to come. Not only could these exhibits be immediately integrated into the museum's floor spaces and layout, but they were expected to be on display or available well into the future.

Aligned with organizational goals and had few barriers to public engagement

Similar to other NISE Net offerings discussed in Chapter 4, an appeal of the *Nano* exhibition was that it allowed museums to meet their organizational goals. Some of these goals, such as the necessity that museums provide novel experiences for repeat visitors, were general and shared by all of the museums, but some were particular to individual organizations. In these cases, the museums altered or added to the exhibition to support their own organizational priorities. The fact that the *Nano* exhibition aligned with the organizational goals or could be easily adapted meant that it was viewed as a long-term asset.

Staff members at all museums told us that the *Nano* exhibition helped them provide something new for their visitors; in some instances, the content was important, but some staff members expressed less interest in the content and quality of the exhibition than in the opportunity to fill available gallery space. Overall, staff had the impression that the *Nano* exhibition helped them achieve their goal of presenting new experiences for their audiences:

> It's broadened the information that we give out. We always have space stuff and the
> dinosaurs come and go, but we don't ever get a big exhibit about nano . . . I like having
> the various forms of science represented. (OSSC#9)

Staff members also explained that a strength of the *Nano* exhibition was that it presented cutting edge, serious science, which they wanted to include more of in their public offerings. Staff at several museums reported that their organizations were interested in becoming—and being perceived as—not just exclusively as children's museums but as settings that engaged visitors of all ages with science and other STEM content. The *Nano* exhibition helped them provide more up-to-date science for their visitors, and staff cited this as a prime reason the exhibition would be sustained into the future. As one staff member said, "I would say [the exhibition is] something that would remain because it is so new and so cutting edge and it's interesting. . . . It appears incredibly durable" (LPSC#16).

For some museums, the *Nano* exhibition was a way to advance particular goals. The museums often altered or enhanced the exhibition, and this flexibility allowed *Nano* to be better integrated into the long-term exhibit offerings. For example, staff at LPSC said that for all their exhibits they incorporate elements to connect with their workforce development goal to inspire children to learn about STEM careers in the region. By highlighting local scientists and careers in STEM, the *Nano* exhibition was able to be easily aligned with this standard exhibit criteria.

Overall, the fact that the exhibition allowed museums to meet both general and specific goals helped the exhibition to be valued as a long-term resource.

Indeed, the majority of staff talked about the positive impact of the *Nano* exhibition. However, because of the small size of the exhibit, the potentially difficult content, and the lack of interactives a few staff members at different museums expressed the concern that the *Nano* exhibition could be a barrier to increased public engagement. One staff member voiced concerns about the difficulties of getting young children to understand the message behind the tippy table:

> Something like trying to level that round table, probably not calling it the right thing, but finding the balance? You know, I thought this was going to be a lot of fun. This was something that kids were going to have fun with and get engaged with. [But] . . . they're just more interested in seeing it bounce around and the little houses are flying off. You know? You go over and [say], "You've got to try and find balance and think about your neighborhood or whatever," and they're just not interested. (LPSC#9)

Yet, overall, only a small minority of staff members worried that the exhibition might not attract or engage many visitors. Instead of focusing on barriers related to the *Nano* exhibition, most staff felt it was a valuable experience for visitors and fit with their organization's goals. Because so many staff were positive and enthused about the *Nano* exhibition, it was seen as an offering that was well suited for engaging visitors and for being on view for significant lengths of time.

Less vulnerable to programmatic barriers and readily on display

The *Nano* exhibition and nano-related exhibits built by the museums were less susceptible to the internal factors that affected public programming. Even if there were staff changes or sudden modifications to the daily schedule of events, the tangible and public nature of the exhibits meant that visitors and staff were still able to interact with nano content. Thus, by being visible out on the museum floor, exhibit experiences, either created or aided by NISE Net, were able to generate long-lasting nano public offerings.

Because these nano exhibits did not necessarily rely on staff members to facilitate them, no scheduling or workload barriers interfered with visitors' engagement with them. As one staff member at OSSC stated, the exhibition is "helping guests that come in learn about nano without us having to do anything" (OSSC#2). Another staff member at this organization emphasized:

> Having the exhibit here has made it easier to convey that information. Like I said, we don't always get to do those [little] demos [related to nano], but [the exhibition is] out there and that's another way to interact with the guests and teach them, "Hey, nano is everywhere! And it's really helping us in all these various places." (OSSC#9)

A staff member at CMSC, in looking ahead to getting the exhibition, also commented on how *Nano* would help increase visitors exposure to the topic by being directly out on the museum's floor. He explained that because only a few staff are typically involved in implementing nano programming

getting the nanoscience out there . . . [has] been tough for us . . . if [my colleague] doesn't do it or I don't do it, it's not going to get done. . . . So, you know, first and foremost [the exhibition] puts nano on the floor in public view. The public interacts, you know. And now they start learning about nano. (CMSC#1)

Clearly, because these different nano exhibits could be viewed at any time they offered a constant and flexible way to expose the public to this content. As mentioned above, the fact that the exhibits were out on the floor for long stretches of time further supported the public's ability to learn about nano as they explored the museum's exhibit halls on their own.

Moreover, the public visibility of these exhibitions helped engage broad segments of the staff with nano content. As discussed in Chapter 5, when information was shared widely among staff, there was a greater chance of it being embedded into practice and leading to long-lasting changes. This was particularly the case if staff left and others were still able to incorporate nano content into their work.

All together the fact that nano exhibits were able to become part of the museums' permanent collection, were aligned with sites' organizational goals, were less prone to programmatic barriers and, thus, able to always be on display were primary reasons why exhibits seemed to lead to long-lasting changes in public offerings.

C.6.2 PROGRAMS

In addition to exhibits, Network Core Partners sought to increase the capacity of partner museums to bring information about nano to the public by building their ability to engage visitors in nano-related programs and demonstrations. The Network Core Partners provided numerous resources that partner museums could utilize to develop these programs and to engage visitors in this content. Many resources were available in the NISE Net online library of resources (www.nisenet.org), including hundreds of nano-related activities, lesson plans, ideas for theater presentations and other shows, guides for creating adult programs such as Science Cafés, and general information about developing and delivering programs. NISE Net meetings and professional development workshops provided additional opportunities for museum staff members to learn about new activities, methods for bringing them to the public, and additional resources such as mini-grants, that could be used for the creation of nano-related programs (among other projects). Participating in the annual NanoDays celebration allowed hundreds of partner museums to engage their visitors in a wide range of activities and programs that incorporated nano content. Hosting *Nano* led museums to deliver special events marking its opening and was, occasionally, an impetus to develop new programs that could be delivered in conjunction with the exhibition.

Our research indicates that museums increased their nano programming by being involved in the Network and that the NanoDays kit materials supplied by NISE Net were particularly useful. It also suggests that while the nano programming was a change for museums, it was not necessarily long-lasting. Reasons why programs, unlike exhibits, seem to lead to short-lived changes are described at the end of this section.

C.6.2.1 Museums increased their nano programming through a range of activities.

Museum partners increased their nano programming in a variety of ways by being involved in the Network. The museums incorporated nano into their on-site and off-site activities and occasionally into their promotional work. This nano programming looked different in each of our organizations, but often included brief demonstrations or cart activities, summer camps, or theater-based presentations. Sometimes this involved putting nano content into current practices they were already doing while in other instances this involved creating completely new programs. For most of the museums in our study, incorporating nano into their programming was something they had never done before, and this change in practice was due to participation in NISE Net.

When explaining how they integrated nano into existing activities, staff members commented that the content often enhanced current offerings. For example, one staff member said that although NISE Net's activity about refraction (Invisibility Cloak) was not new to her, it did introduce nano connections that she had not thought about:

> Yesterday when [other staff] were showing us the, the Invisibility Cloak, we've been doing that since I started here. So, you know what I mean? It's stuff that we're already doing, but we can actually bring the nano twist to it, which is so cool. (CMSC#5)

At LPSC, nano content was able to be incorporated into their monthly TV spot on a local news station on which they rotate science topics. One staff member explained, "This year we're doing all Year of the Human Body but we have done a nano [program] in the past [with] . . . some nano activities on that show" (LPSC#11). At YESM, nano activities were integrated into an engineering program. Here, the museum "worked with the girls engineering club of [the museum and had] taken some of the nano activities into that engineering group for middle school girls" (YESM#1). These examples show that nano content was seen as directly relevant to topics that museums were already covering and as an innovative tie-in with current programs, even if it had not been previously part of these efforts.

Besides adding nano elements into existing programs, with the help of NISE Net resources, sometimes in the form of mini-grants, museums were inspired to create new nano-specific programming. In doing so, they often fit these brand new nano programs into existing formats used for other content, such as summer camps or live-presentations. For example, were it not for a mini-grant at OSSC, one staff member said they would never have done a summer camp for 5th graders devoted to nano. In recounting how this program developed, she said that they had "never thought about doing a camp with nanotechnology until we got the mini-grant and had talked about that and we were like 'oh yeah, why don't we try this?'" (OSSC#1). Likewise, at LPSC, with the help of a mini-grant, staff developed theater programs about nano content. They drew on information available in the NISE Net online library of resources and turned it into live-programs which helped them fulfill their programming "niche" (LPSC#5). One staff member explained, that without NISE Net,

> We probably would not have done the programming without it because it's, it's a lot of money to develop a program and to dedicate staff time . . . We have an electricity one, a liquid nitrogen program, one on light. We had nothing on nanotechnology. And I think

if it's something we want people to start hearing about and understanding, I think it was great. So it really did fill a gap in our program menu. (LPSC#5)

These examples indicate how adding nano content into programming was a change in terms of the work that the museums had been doing prior to being involved in the Network.

C.6.2.2 Museums, in particular, used NanoDays kit materials for nano programming.

In our interviews, only a few staff members told us that they had drawn on information from the Network's online library of resources and other NISE Net sources to help them develop nano-related programs and activities. Although many staff members were aware of the NISE Net website, most said they were too busy to use it to any extent. Yet, of the various NISE Net resources, it was the NanoDays kit materials, which were given to institutions to help them carry out NanoDays events, which were frequently incorporated into different types of programming.

The NanoDays kit materials received extraordinary accolades from most staff members and enabled museums to expose visitors to nano throughout the year and not just at NanoDays events. Adding NanoDays kit materials to their programming was often seen by staff as a natural progression of their NISE Net involvement. As one staff member from OSSC explained,

I think we're doing more with NISE Net than we did before. In the beginning, it was just learning what it was and just knowing what nanotechnology is, what NISE Net is, but through the years, we've slowly done more. Like in the beginning, we did NanoDays. . . . And then not too long ago we get the *Nano* exhibit and now we're also doing small demonstrations with nano [with the NanoDays kits]. So we're just kind of adding on little by little, more things we can do with NISE Net and the knowledge we've learned from there. (OSSC#1)

According to a staff member at PSSC, by incorporating the NanoDays kits into their everyday programming, "we can continue to do some of the aspects of NanoDays on a regular basis" (PSSC#2). One individual at STSC said that because NISE Net had "provided us with direct kits . . . we [are] expanding our program's offerings and [it] also brings credibility to us to be able to do things that nobody else in town does" (STSC#6). Clearly, staff recognized that using the kits outside of NanoDays events was a way to increase their year round public offerings of nano content.

When talking about programming they did with the NanoDays kits, staff members described a wide range of ways in which they were using materials. The NanoDays kits were incorporated into onsite gallery programming and also used for outreach, including activity tables at community events or school-sponsored family science nights. A staff member at CMSC described her excitement to learn about the NanoDays kit activities at a NISE Net gathering and how they were used at her organization for floor programming:

We did a lot of the activities which was cool during one of the conference sessions, we did a ton of the activities, which was really fun, we learned ways to do them with our visitors and it definitely made me more excited to use all those kits. We have all those kits in the closet and they weren't really used too much other than when we did NanoDays which is what they are for, it's what they are given to us for, but we realized

> just how much more we can use them throughout the year, they didn't just have to be used for NanoDays and that's when we started to add them to our [floor] demos. And then [a colleague] also wrote the mini-grant from that because we wanted to do more of the demos on the floor. (CMSC#5)

LPSC provides another example of a museum that integrated the NanoDays kits into activities that visitors would encounter on the exhibit floor. At this organization's dedicated space for small table-top interactions, specific NanoDays kit activities, including the stained glass and nano gold demonstrations, were used along with posters, nano tattoos as well as Buckyball models that came from NISE Net. One staff member explained,

> On weekends, every weekend, and during the summer, every day, we have one long table space downstairs in our main exhibit floor that we try to have hands-on science demonstrations that everyone can come try out if they like. And we try to change it every month so that our members who come back regularly don't get bored. The one month we had a focus on nano. And I know a lot of the materials we were using were from NISE Net. (LPSC#1)

> Not only were the NanoDays kits used throughout the year, but staff described how they were appropriate for a range of audiences. Sometimes these included general visitors exploring the exhibit halls, school or camp audiences, or groups of people watching demonstrations. One staff member at OSSC who ran large demonstrations explained how he was able to use the NanoDays kits:

> So what I'll do is I'll normally have this big event, and then I'll have smaller key principles that they can come in and kind of play with. And the hydrogel is one of my favorite things. I always talk about the hydrogel and the polymers and the sodium polyacrylate, and I love it! (OSSC#7)

At STSC, staff mentioned how "We have school groups that come, homeschool kids that come and that's when it's really great to pull those kits out" (STSC#2). A staff member from CMSC, recalled how they had used a NanoDays kit activity with one of their youngest audience groups by saying,

> Last year we had a preschool came to me and said they wanted to do some nano stuff and did we have any tools for that? And I gave them the LEGO, the Duplo kit, where, [you are asked to] "build this shape with the Duplos, now put the oven mitts on and build it again." And getting this understanding that even when you know how to do it, if you don't have the right tools you still can't do it. (CMSC#3)

All of these examples indicate just what an important role the NanoDays kit materials played in helping museums increase their nano programming in a variety of situations.

C.6.2.3 NanoDays kits were useful for programming because they aligned with museum activities, adapted easily, and required little staff training.

Because they aligned with museums activities, adapted easily, and required little staff training, NanoDays kits helped increase the amount of public nano offerings. Even if some of

these programmatic offerings, were not long-lasting, staff at all of the museums indicated that these factors made the NanoDays kits appealing to use at one point or another.

Aligned with museum practices

In particular, staff felt that the NanoDays kits were useful for increasing their public programming around nano because the kits fit in with their typical hands-on activities. This type of programming helped them meet their goal of providing new and engaging visitor experiences. As one staff member explained, nano materials were able to supplement the existing work their organization was doing in regards to interactive activities:

> If you go to the daily calendar on our website, you've got science encounters and nano encounters. . . . [it's] new information to share, which if we didn't have NISE Net, would we be trying to do that? Yes, I'd still be trying to do that every half an hour. But NISE Net, I think, in terms of with like the *Nano* exhibit, we wouldn't have nano encounters if it wasn't for NISE Net. (CMSC#5)

> Developing materials from scratch was time consuming and expensive. Thus, the materials from NISE Net were not only a natural extension of what they were doing with visitors but were welcome because they were already created by experts. As someone from CMSC exclaimed, "I was like, 'Wow, this is really cool!' You know? Because usually you run around trying to make up those little kits, and here they are!" (CMSC#7). Someone from PSSC said,

> I think they're awesome. [laughs] I was here when they first came and it was like Christmas. [laughs] Getting to open the boxes that come with everything you need. You just set it out and it's ready to go. And you can't make it any more easy and the information that is with it too, like the little explanation is really great and very helpful too. (PSSC#8)

On Site Visit 1, an individual from YESM noted, "I'm sure all of the stuff we have gotten from NISE Net would have been available to us on our own but the energy, time, and resources it would take to find it . . . would have been prohibitive" (YESM#10).

Adapted easily

Although the NanoDays kits themselves were easy to integrate into their programming, staff also felt they could adapt the kits for their needs. Because of this flexibility, the NanoDays kits were often modified to better fit a particular program or specific format. One staff member at CMSC described the variety of ways that he had adjusted the NISE Net activities:

> I fit them into our lesson plan model, and our method of teaching. . . . rather than doing the exact activity that's prescribed by NISE Net or the people that put the curriculum together, um, I changed it to fit our curriculum. . . . anywhere from length of time of activity, so we may have cut the activity a little bit. We may have used it as a demo instead of a hands-on to just introduce topic. Uh, and we may have, in some cases, tried to make our own stuff. (CMSC#1)

Similarly, a staff member at OSSC talked about how they modify the kit materials when using them for larger programs outside of NanoDays events:

> Like with NanoDays we might have a few hundred people, but they come through one at a time, but if I'm going to use it for a demo . . . I might have to adapt it as far as either materials or just making sure what's happening is more visible for that size crowd [of 30-50] so that everybody gets a sense of what's happening. (OSSC#2)

Staff at OSSC also mentioned how they modified the NanoDays kits by combining activities together, thus, allowing them to cover other content areas. As one staff member indicated,

> So we're actually working on a material science demonstration right now. And so with that we took like ferrofluid from the kit and we took the pants the water rolls off and things like that and then we're also adding other things like aero gel and magnetic putty and some other things to that to talk about material science. (OSSC#1)

At STSC, staff also made connections between nano and other topics and modified the NanoDays kits to convey different areas of science. One staff member who focused on astronomy explained that

> the experiment when you take the little tiny cup and you turn it and nothing comes out? That works in astronomy in reverse because you can show someone that the normal way you think of the laws of science change[s] with scale. Take a look at this! Hah! Water won't come out! What do you think when it's huge? So it's using nano to explain something else. (STSC#4)

Overall, in describing the ability to modify the NanoDays kits, one staff member summarized how "it gives you all the content you need and then you can change the actual activities to better fit your audience. But the content is there so you feel comfortable with what you're changing." (LPSC#5)

Required little staff training

Staff also noted that, in part, the NanoDays kits were easy to incorporate into their public programing because they could be used by almost any staff member. Indeed, at our museums, full-time and part-time staff along with volunteers were all involved in facilitating the NanoDays kits. As one staff member said, "For NanoDays, because they come so complete with the instruction cards, all the information is right there. I could really just give it to somebody and say 'Read that card' and go to town with it" (OSSC#2). At PSSC, volunteers from a local university could easily help out at NanoDays events even though they were not the museum's

> normal core of volunteers . . . [and despite the fact that] many of the students were not necessarily science students. But because of how well prepared the activities are, they could jump right in with a little bit of training from our staff and execute the activities and talk with our guests. (PSSC#6)

Although a Senior Leader at YESM on Site Visit 2 viewed the NanoDays kits as a "fallback" activity that was appropriate for high school interns because they did not require much

intensive training, this reflected the museum's changing goals rather than a criticism of how easy they were to use (YESM#1). As described in section B.4.3, by the second site visit YESM was moving away from demonstration-based programming, such as the NanoDays kits, and towards open-ended activities. Yet, in general, staff at the sites described the format of the NanoDays kits as "brilliant" (LPSC#1) and felt they could be used by staff or volunteers without much training, thus, making them key resources for public programming.

C.6.2.4 Programs often led to short term changes in public offerings because they were vulnerable to changes in museum exhibits or goals, susceptible to staffing conditions, and affected by other contextual factors.

Being involved with the NISE Network certainly led the museums in this study to increase the number of nano programs offered. However, even though the museums added this content into different activity formats, these efforts generally did not lead to long-lasting changes. By Site Visit 2, many of the initiatives that were seen on Site Visit 1 had tapered off or ended. This section describes several reasons why programs, in particular, seemed to lead to short-lived changes in the museums public offerings.

Vulnerable to changes in major exhibits or museum goals

Museum programming was typically an extension of the museums' missions, goals, or currently featured exhibits. If any of these changed, it was likely that programming was also affected. As one staff member from OSSC explained,

> We might take a month and do a lot of nano stuff like in December I have a lot of nano activities planned and that's going to push stuff and people are going to be a little bit aware, but then when January hits and our Robotics exhibit leaves and our dinosaur exhibit comes in, nobody is going to be thinking about the nano anymore. (OSSC#2)

YESM, too, was a museum where a new exhibit affected the amount of nano-related programming. In particular, the Tinkering Studio which focused on open-end experiences and grew out of changing organizational goals, had a major effect on the museum's overall approach to public programming. As section B.4.3 described, by the second site visit, YESM had moved toward a "curiosity-based" learning style which was "less about knowing and more about doing" (YESM#4). This shift in focus led to the development of a tinker space and a revised way of thinking about how to engage visitors on the floor. This included fewer demonstrations and less use of pre-packaged activities in which the endpoint and steps to get there were set by the developer. Instead, visitors pursued more hands-on, open-ended engagement with materials with which they decided on their own questions and directions. NanoDays kits, which had previously been implemented through floor programs, were now seen as examples of the old way of working with visitors. As one staff member explained,

> I think we used to be okay with experiences that were very demonstration-based or very information-based. . . . Now I think we're really pushing to provide opportunities for people to try something and discover. That's always been true with our exhibits, but I think it's more so now true for our programming. We're less "Make and Take" arts &

crafts, and more "What can you figure out by doing with your hands?" . . . So part of the challenge is then translating things that we think are really cool to see, and finding a home for them if they are no longer meeting our bar for activities. . . . That actually happens a lot with the NanoDays activities. (YESM#4)

Another staff member felt that NISE Net was "missing an opportunity, because you should make a kit that can go in a make[r] space. Here is the kit for free, refill it for $20 when it is empty." (YESM#2) At YESM, it was evident that changing organizational goals and new exhibit space were affecting the type of public programming that was offered. Although the NanoDays kits had once been seen as useful for engaging visitors, they were no longer being used as often and had not led to lasting nano programming.

Susceptible to staffing changes or constraints

Another main reason why many of the nano programs had difficultly lasting for multiple years was that staffing changes occurred at our museums. With the departure of staff or switching of roles, public offerings were often affected. Not only did changes in staffing sometimes put pressure on scheduling or capacity, but they also sometimes meant that programs stopped because the person who created or implemented them was no longer involved.

The departure of staff at YESM meant that their nano theater show created as part of a mini-grant essentially ended. For this program, nano activities from NISE Net related to stain resistant nano fabric had been integrated into presentations for school field trips:

They would usually get a teacher to come up on stage and . . . she'd wear the lab coat and she'd sit on a stool over a kiddie pool and they'd pour grape juice on her and water on her and she'd stand up and she'd be perfectly fine, and the kids just got a huge kick out of it. (YESM#10).

Yet after changes in the education department which led various individuals to move on to other jobs, one staff member explained that because of staff shifts it had been roughly four months since it had been staged.

At LPSC, too, the departure of a staff member also affected two public shows about nano. The museum had integrated information from NISE Net products into these shows. But, following the departure of staff, these demonstrations did not remain part of the ongoing programming. One staff member explained,

So there is not a whole lot of cross training between our guest experience staff versus education staff as well and so I think that might've been part of the discrepancy in disseminating information. . . . and you need people to be a certain personality to do it . . . And yeah, he was one of our great part time staff. I'm not sure that anybody else really learned the show. (LPSC#7)

General staffing constraints also affected public programming. In particular, during busy times or when organizations were understaffed, programming often fell to the wayside. This was the case at PSSC on Site Visit 2 where nano cart demonstrations were not being run consistently. As one staff member said,

>We just don't have the staffing to pull that out anymore. We only have that out really on NanoDays, or maybe some special days when we're doing other things . . . but we just don't have the staffing right now to do that. (PSSC#4)

Another staff member said that these might pick up during the summers when they have volunteers "but right now we are in the middle of season and I can tell you that we have not done cart demonstrations!" She went on to explain that this is, in part, due to the fact that

>we're definitely growing as an institution, but our staff is not growing because we're a city facility. . . . So we're busting at the seams, so we've had to sacrifice some things like the cart demos and little things, in order to just to get our everyday operations under control! (PSSC#1)

The upcoming case study, which highlights OSSC, also sheds light on how on-the-floor programming can get cut if there is not enough staff time to carry out essential duties. Moreover, this case study provides an example of how staff departures, also mentioned in Chapter 5, led to slow transitions of knowledge which often hindered the continuation of nano programming. Overall, data indicate that because programs are typically facilitated, they were vulnerable to changes in staffing and often had decreased lifespans. Certainly barriers such as staffing changes and shortages forced our study museums to discontinue some of the nano programming that was underway on Site Visit 1.

Affected by other contextual factors, including visitor interest

The lifespan of programs was also vulnerable to additional factors including spacing constraints or wavering visitor interest. For example, at LPSC, space for on-site programs and demonstrations became limited when the museum brought in more traveling exhibits:

>We're having trouble getting our public programming on a more routine basis, because the place we used to do them, which was our theater, is now being turned into an exhibit space. So we're kind of trying to re-work that, figure out what we need to do to get the public programs up and running again. (LPSC#5)

If programs were not popular with visitors or became stale, they were often cut from the rotation. At a few of our museums nano camps were susceptible to low sign-up numbers. At OSSC, the nano camp ran for a year but was never revived. A staff member at another museum also felt that low numbers might affect the lasting nature of their nano camp:

>I don't know about the camp [if it will last], our camps are min of 10 and max 20 and I think they only had 9 people but they ran it anyway, so I don't know if they will try again. (CMSC#5)

Even NanoDays, one of the primary nano programs at our museums, was not always an event that would continue long-term. Although some museums felt this program would continue for at least a year or two, others indicated they might stop running the annual event. In considering the future of NanoDays events, one staff member at OSSC explained, "I don't know if we would have the initiative to continue doing a Nano Day? Just because if we have the same kits every year, year after year, I think people would start catching on" (OSSC#13). A staff

member at YESM also acknowledged that their NanoDays programming was not a sure bet in the future because it was the type of event that could be seen by visitors as repetitious or easily affected by other recreational opportunities, outside of the museum:

> We've been really looking at, "so which are the things that actually gets people in the door". . . and I know that when I first got here, NanoDays, we did some full on NanoDays programming. Second year, we changed the programming a little bit . . . instead of having each of the NanoDays kits running all day long it was okay, here's the segment of time for this one here, so there's a calendar of things that happened through the day that worked better. But, we started to see that people, "oh NanoDays, oh you did that last year" and there's a lot of competition in the area for things on weekends, particularly in the spring when finally the weather's nice. (YESM#1)

These examples highlight how underlying contextual factors, such as space and visitor interest, often influence museum programming. The following case study showcasing OSSC provides an overall snapshot of how NISE Net resources have the potential to prompt sustainable change in programming, but also points out why they can be vulnerable.

Case example: OSSC's employment of NanoDays kits in programming and barriers that arose

OSSC provides an example of how a partner museum increased its nano programs by incorporating the NanoDays kits into both onsite and outreach programs. This case also provides insight into why programmatic changes were sometimes only short-lived.

During Site Visit 1, OSSC staff were making a push to bring NanoDays kits out of storage and start using them more often instead of only at NanoDays events. Staff members explained how the NanoDays kits were used at summer camps, for outreach, and in the newly created floor demonstrations. For these demonstrations, part-time educators were encouraged to put together small sets of activities that could be taken out on the floor and used for quick guest interactions. Staff cited nano materials from the NanoDays kits as an especially good fit with this initiative: "You can just go in and grab it [a NanoDays kit] and walk around" (OSSC#9).

Museum educators even brought the NanoDays kits to an outreach event at a local fast-food restaurant, providing science activities during the monthly kids' night. Typically, two educators went out and did a couple of activities for the families. One staff member described these evenings:

> It's more or less just, like, a couple of us doing activities with the kids, and so we'll take nano stuff just about every time we go. Because it's always so interesting and kids really want to know what's going on they're like, "Why does hydrogel do what it does?" And so that's always fun to kind of explain that and then they get to take it home, you know, some of the things they get to take home, um, like the thin films thing. (OSSC#8)

At OSSC, staff members were enthusiastic about the NanoDays kits because they were easy to incorporate into demonstrations and programs. As one staff member said the NanoDays kits offer, "a lot more to talk about. I mean it is so cool to throw something nanoscale out. . . . While you're doing a demo and you're talking about stuff that everyone can see and everyone

can feel, and it's very palpable" (OSSC#7). Other staff explained how information and activities from NISE Net were valuable because the nano content could transfer to other scientific topics. At OSSC, staff viewed the NanoDays kits as containing not only fascinating information about nano but also useful facts to tell visitors:

> The kits are amazing. Like, I love the fact that each activity is in its own box, it comes with everything. And I also love that they tell you not only what to do, but why it's happening, like the actual background information, because that's what we want to know so we can have enough information to teach people about what's going on. (OSSC#1)

Overall on Site Visit 1, the NanoDays kit usage increased the amount of nano that was occurring with the public at OSSC.

However, by Site Visit 2, the NanoDays kits were not used as often during OSSC programming. External factors such as increased visitor attendance and busy staff schedules impacted whether or not staff were being trained or encouraged to use the nano activities with guests. For example, when asked whether or not they were still doing nano as part of the quick floor demos, one staff member reported,

> I'm not sure. I mean I'm not sure how much more often the [little] demos are being utilized because it's been so crazy and hectic and busy I'm not sure if people have been going and using them as much as we used to, but that also falls on [the fact that] we have newer people that don't really know about them. (OSSC#9)

Another staff member said there had "been a lapse" because some of their part-time floor staff had left and it was difficult to retrain the new staff. As she said, "the small kits are just kind of . . . extra things for our staff to do. So it's not like a priority." (OSSC#1)

Staff members on Site Visit 2 also talked about how their use of the NanoDays kits at the local restaurant had declined and how some staff did not even know whether or not the kits were being used off-site. This decrease in public programming may have been due to the fact that the full-time manager, who had been involved in NISE Net and the outreach, had left the museum. As noted above, staff turnover of part-time educators may also have contributed to the decline of awareness about nano activities at OSSC. Thus, unlike the situation on Site Visit 1, when many staff were talking about using the NanoDays kit activities for outreach, one staff member reported decline in use though she had recently encouraged the new manager to take advantage of these kits: "Hopefully in the future . . . they'll pop up more. Because again, I told him, why not use them? They're easy, you just take the box, and, you know, you go!" (OSSC#1).

Although staff changes, other museum priorities, and time pressures influenced the frequency with which nano was being presented to the public at OSSC, by the time of Site Visit 2 the NanoDays kits were being used with new audiences. They were now starting to be introduced to school lab programs. As the staff member in charge of this work explained, "I've taken activities from it and incorporated those into the labs . . . [I] go buy additional materials because it doesn't come in a classroom set for 30 so I just buy the extra materials and build that in" (OSSC#15). Thus, even though data indicated that the NanoDays kits were used less frequently with museum visitors, staff members at OSSC were finding new ways to incorporate the kit into their work related to schools.

Taken together, the experiences at OSSC on Site Visit 1 and Site Visit 2 show that the NanoDays kits and involvement in the Network had brought about programming changes at the museum. Without these materials, there would have been little to no nano programming at OSSC. Nonetheless, this case also illustrates that programming can be susceptible to a variety of factors, and that the continuation of public offerings is not always guaranteed even if materials are on-hand and staff interest was high at some point.

C.6.3 SUMMARY

This chapter's findings illustrate how participation in NISE Net changed organizations' exhibit and programming practices. Before joining NISE Net, most of the organizations had no nano content available for visitors, but with the help of the Network's resources, each of the museums added new or additional nano exhibits and activities to their public offerings. By Site Visit 2, all six of the sites had or were about to receive the *Nano* exhibition, and three sites had created nano-related exhibits with the help of NISE Net's mini-grants or outside scientist partners. Programming typically involved nano content being incorporated into current activities, such as hands-on demos, or new-nano specific offerings, such as, theater presentations, or summer camps. For this programming, the museums frequently turned to the NanoDays kit materials from NISE Net.

Our analysis reveals that exhibits, as opposed to programming, seemed to lead to long-lasting changes in the museum's nano offerings. Exhibit offerings were typically incorporated into a museum's practice, sustained over several years, and anticipated to be on view in the future. Programmatic offerings, on the other hand, were short-lived because they often had been discontinued by Site Visit 2 or were not expected to last. In this chapter, we presented various factors that led to and impeded lasting organizational change in public offerings.

Although NISE Net's resources certainly gave the impetus for all of the museums to provide nano programs, especially at the time of Site Visit 1, other factors played a role in whether or not the programs continued and created lasting change. For each of the museums, constraints affecting the work of their community of practice (Chapter 1) specifically impacted programming. As was seen, programming often required human facilitation and was subject to staffing changes and demands. In addition, programs seemed to be more dependent on visitor interests than exhibits. Public programming was also susceptible to exhibit overhauls or changes in approaches to museum goals. Goals, as described in Chapter 4, are at the core of communities of practice and when they don't align with outside forces then the likelihood of change was diminished.

Exhibits, on the other hand, led to long-lasting changes in museum's offerings because they were incorporated into the museum's collections and expected to be used in the future. Moreover, museums could add content to the exhibits that allowed them to meet their organizational goals, such as highlighting local STEM scientists. The *Nano* exhibition, which was seen as having few barriers to engagement, was also able to provide repeat visitors with new, STEM experiences. Exhibits were less vulnerable to factors that affected programming, including staffing changes or workload barriers and were always on display. Therefore, the flow of information about nano to visitors and, even staff, was constant. As described in Chapter 5,

when information was shared widely among a community of practice, there was the possibility of change on an organizational level.

Although the NanoDays kits provided physical resources, unlike, the *Nano* exhibition they often did not result in longer term change. This was because programming requirements went beyond just having the actual objects. Thus, even though the NanoDays kits were tangible materials that often aligned with the work of the museums and provided easy to use and adaptable resources, they could support programming only under certain conditions. While there were certainly museums within this study that planned to continue using the NanoDays kits and nano in their programming, this research highlights a number of barriers that interfered with museum programming, as opposed to, exhibits.

CHAPTER 7. CHANGES IN STUDY MUSEUMS' PRACTICES UNRELATED TO NANO CONTENT

In addition to introducing nano content into programs and exhibits at partner museums, NISE Net encouraged museums to adopt practices that were not specifically related to the scientific aspects of nano. For instance, NISE Net advised museums to consider incorporating ideas about the personal and societal costs, benefits, risks, and uses of nanoscale science and technology into their public offerings. They also suggested that partner museums employ universal design principles in their work to make public experiences as accessible as possible for all visitors and that they provide bilingual programming and exhibit text. NISE Net promoted these practices first and foremost by applying these principles in its own products, including the NanoDays kit activities and the *Nano* exhibition. The Network also offered in-depth professional development meetings, webinars, and guides that provided specific strategies for integrating these practices when creating and delivering programs. Brokers, or key staff members who took part in the Network activities, often were introduced to these resources and practices at gatherings and through other Network communications. The Network Core Partners also promoted the use of particular approaches for how museum professionals might engage both visitors and other staff members around nano and other content, such as the use of open-ended questions, conversational techniques, role play, and improvisation. In this chapter, we discuss several of these practices: incorporating content about the societal and ethical implications of nano into exhibits and programs, using new techniques to engage staff members and visitors, adopting ways to evaluate museum experiences, including more than one language into exhibit text and programs, and using universal design principles to make public offerings accessible to everyone.

Throughout the chapter we note both staff members' enthusiasm for these practices and their waning interest over time, resulting in a lack of implementation and little sustained change, which we attribute to structural and other factors. Although the museums often greeted these new topics with great eagerness, and NISE Net modeled new practices and provided training and resources to help museums incorporate them into their work, we rarely observed long-lasting change around these areas. In this chapter, we discuss where, if at all, changes in practices beyond nano content were seen at the six research sites and why long-lasting change appeared to be so difficult.

C.7.1 SOCIETAL AND ETHICAL IMPLICATIONS OF NANO

NISE Net introduced many museum professionals to the idea of incorporating societal and ethical implications of nano into their work. Components of the *Nano* exhibition and the NanoDays kits illustrated how, in addition to learning nano content, visitors may be intrigued by the risks and benefits of nano-related technologies. NISE Net helped partner museums incorporate these issues into their offerings by providing examples of possibilities and concerns related to nanoscale science, engineering, and technology.

Besides sharing these ideas through NanoDays kit materials and the *Nano* exhibition, NISE Net held related professional development experiences. During 2012, Network Core Partners offered staff members at partner museums across the country the opportunity to attend two-day Nano & Society Workshops. Workshop participants also received a kit that included

materials to train staff at their home institution, and a few hands-on activities to use with the public. These workshops presented "three big ideas" related to technology and society and included information on how to engage public audiences in open-ended conversations that focused on their values and opinions regarding emerging nanotechnologies (henceforth called Nano & Society content). Staff from four of our six museums participated in these workshops. A later guide (Wetmore, Bennett, Jackson, & Herring, 2013) made publicly available on NISE Net's website summarized many of the ideas that were shared in these workshops. Nano & Society ideas were also communicated at other Network gatherings, such as regional and Network-Wide Meetings. Some of NISE Net's suggested techniques for engaging visitors in conversations about societal and ethical implications of nano included "let visitors' interest guide the conversation," "use examples from everyday life," "offer additional information or a different perspective, but maintain a neutral position on issues . . . or say 'I don't know'" (Sciencenter, 2012, p. 1).

C.7.1.1 NISE Net generated considerable interest among many of the museums to present societal and ethical implications of nano and to use conversational techniques.

During Site Visit 1, many staff members expressed a high level of interest in presenting Nano & Society information to their visitors. The initial round of site visits took place in 2012, soon after the workshops, so timing likely played a part in these findings. Nonetheless, for many of the people we interviewed, the societal and ethical implications of any scientific topic was a new area, and they were excited to incorporate these types of discussions into their work. As a staff member from the Outreach & School-focused Science Center (OSSC) explained when talking about what he wanted to do differently after attending the Nano & Society Workshop,

> It's gotten me into really thinking about implications of these things, of anything. So it's really started me in all of our programming wanting to, I don't always do it, but at least wanting to ask people why they think this stuff is useful or if they think it's useful, for any program, like I said, not just the nano stuff, for anything we do. (OSSC#2)

Commenting on her experience at the Nano & Society Workshop, a staff member from the Pursuing STEM Science Center (PSSC) said that in addition to receiving new activities to use with visitors, she took away ideas for how to cover this topic:

> [I learned] that it was okay to talk about some of the implications of this, you know? That it was okay to be open to people who wanted to talk about the implications and not feel like I have to be like, "Well, no! It's all daises and sunshine." (PSSC#1)

Even staff who had not gone to the workshops reported they had heard about societal and ethical implications from NISE Net and were looking forward to implementing the conversational techniques. As one staff member from PSSC described, "That's something that we hadn't discussed as much before and nano provides such a platform to do that and so now . . . we're looking at doing some adult programming that we never would've done otherwise" (PSSC#6). At the Local Partners Science Center (LPSC), one staff member noted that nano "is not the boogeyman, this is not a dangerous technology per se, we need to have a conversation

about how we use it. And . . . [highlight] the, as I said the social applications, the safety issues" (LPSC#3).

In particular, staff often recognized the conversational strategies from NISE Net not only as a new way to interact with guests but also as a fresh approach for training staff. On Site Visit 1, several museums were beginning to encourage staff and volunteers to facilitate these conversations. One staff member indicated that at PSSC,

> We do [the] invisibility cloak and we do the You Decide cards [two activities presented at the Nano & Society Workshop] and we always train those volunteers to talk more . . . like it's a conversation. [We say to them,] "You have a nice job sitting there because you're just literally talking to these people and [asking them] what do you think about these cards?" (PSSC#1)

At the Young & Evolving Science Museum (YESM), a staff member said she was going to use the *Nano* exhibit to help volunteers think about what technology means to our society: "Oh, I can't wait for the exhibit to open so I can start, you know, facilitating some of these activities or teaching my volunteers to facilitate the activities" (YESM#7).

Overall during Site Visit 1, staff members at most of the study museums indicated that NISE Net's Nano & Society ideas and resources had changed how they approached their nano work. Staff also felt these conversational techniques could transfer to any social-scientific issue. Specifically, staff at several museums planned to incorporate ideas from the workshops into their programs and trainings and share this information with others in the organization.

C.7.1.2 The excitement surrounding societal and ethical implications of nano and the use of conversational techniques was often short-lived.

However, by the time of Site Visit 2, this high level of interest had diminished at our sites. Although on Site Visit 1, several staff members were excited to modify their staff and volunteer trainings to offer new information and techniques related to Nano & Society content, this was not occurring widely during Site Visit 2. Few staff members on Site Visit 2 provided examples of how they were engaging visitors in discussions about the societal and ethical issues associated with nano or other scientific topics. Instead, barriers to implementing Nano & Society work were cited. Some staff members who had attended the Nano & Society Workshops had left their organizations, and others mentioned a variety of factors that stood in the way of presenting the topic and using these new techniques to engage visitors.

The departure of key staff at three of the four sites which had participated in Nano & Society Workshops reduced the emphasis on societal and ethical implications. Even though two staff from each organization had attended, on Site Visit 2, data indicate there was typically less sharing of information about Nano & Society or the conversational techniques. Not only had a significant amount of time passed since the workshops, but job responsibilities and level of interest from the staff who remained for engaging visitors in this manner did not always support the continuation of this work.

At OSSC, for example, on Site Visit 1 one of the staff members who had gone to the Nano & Society Workshop was eager to share information with the part-time staff he oversaw.

He wanted to tell them about the *Nano* exhibition's societal connections and give more explanation of "What this [tippy] table is really for! . . . If you're playing with somebody, here's what you want to talk about, here's what you want to bring up and mention" (OSSC #2). However, on Site Visit 2, after he left the museum, some of the part-time staff indicated they were less aware of NISE Net related-information, in general, with one individual stating: "I'm not sure who's taken over that now to even get that information from" (OSSC#9). The other staff member who had attended the workshop reported she haven't shared anything recently about Nano & Society because "it was so long ago" and the information and activities she had learned hadn't "stuck very well" (OSSC#2). The case example that follows this section indicates how the loss of staff at YESM also impeded the continued work around societal and ethical implications.

Additional barriers that staff mentioned on Site Visit 2 included feeling that visitors would not enjoy talking about the risks and ethics of nano, that these topics were too controversial for their geographic region, and that doing so did not align with the goals of the organization or the belief that museums should present only scientific facts. A Senior Leader at OSSC argued that visitors needed to know more about nano content and other, more relevant scientific issues before they were asked to consider the societal and ethical aspects of nano:

> I still think people need to be more aware of just the basics of nanoscale science before they get to those issues, to those higher level issues. . . . There's probably many more topics that would probably be more important [for this area]. Sort of cost-benefits of you know, fossil fuels, energy, and global warming . . . water use, things like that. . . . I mean, goodness, you'd probably be better attended having one on the fallacies of the anti-vaccine movement . . . than you would from materials . . . modified due to nanoscale. (OSSC#4)

Another concern was that Nano & Society content was difficult to incorporate into school programming. One staff member at the Small Town Science Center (STSC) described how these concepts

> didn't really come up with the school groups because I think it's harder to have group discussions like that with school group kids and they are here to have fun . . . As soon as you start having any kind of discussion like that, poof! They are gone. They want to finish their Fritos so I think it would be nicer if the parents were there to have this discussion. (STSC#2)

Staffing constraints also factored into whether or not engaging visitors in Nano & Society issues had been integrated into museums' long-term practices. At PSSC, one staff member who had gone to the workshop explained,

> We've got that curriculum from Nano & Society about all those really nice visitor interactions that you can have in the exhibit. We have that on hand, [but] as far as implementation that probably won't happen right off just because we don't have the staff. (PSSC#1)

Thus, even though there had been excitement and trainings at several sites related to Nano & Society and ways to engage visitors in conversations about values, by Site Visit 2 this had generally dropped off. There seems to have been an overall loss of interest and lack of

implementation of Nano & Society content and open-ended conversations with visitors at the museums. The case example below provides an in-depth look at why the initial enthusiasm surrounding these issues at YESM was not sustained.

Case example: YESM's challenges integrating Nano & Society content into its practice

YESM provides an especially rich example of short-lived change around the practice of engaging visitors in Nano & Society content. At this site, a misalignment of goals and staff turnover eventually hindered the initial enthusiasm for this work.

On Site Visit 1, staff members in a variety of positions discussed their knowledge of activities from the Nano & Society Workshop and told us that engaging visitors in discussions about the societal and ethical implications of nano was a new, but very important, undertaking. Two staff members had recently attended the workshop and returned excited to engage the public in conversations about the costs, benefits, and risks of nano. Soon after the gathering, they presented ideas about the societal impacts of nano at a staff meeting and incorporated them into a volunteer training related to the *Nano* exhibition. The Nano & Society activities were then utilized at the exhibition opening, which was attended by other staff members.

In talking about which ideas and practices from NISE Net might be adopted broadly in the museum, a Senior Leader of the organization, noted this new way of engaging visitors:

> The thing that I would anticipate, if my crystal ball was polished up, would be the notion of having conversations, discourse, about the social implications of the technology is new for us . . . In some ways, it opened the eyes of some of our staff that, "You know, this doesn't feel the same . . . We should do this more often." (YESM#1)

A museum volunteer who attended the training also commented that this approach felt different:

> This is the first time I've seen questions like that—the implications . . . I hadn't seen that before . . . I have seen more of the, you know, more of the mechanical, more of the scientific understanding behind and the scientific processes, you know, observation, hypothesis . . . but I hadn't seen the values-oriented stuff. (YESM#11)

Another YESM staff member said that this work was "going to push us to ask different questions of kids that aren't just fact or even just inquiry-like." She indicated that they were "not really asking that . . . yet, but I'd sure like to" and talked about how the organization had submitted a NISE Net mini-grant application that would build on some of these ideas (YESM#4).

However, by Site Visit 2, staff members at YESM had not received the mini-grant, both individuals who had gone to the Nano & Society Workshop had moved on, and the museum had revised its organizational goals. Although the museum had always wanted to create a sense of wonder and excitement about the world through hands-on interactive experiences, soon after Site Visit 1 the organization held a strategic planning meeting in which it adopted a curiosity-based learning approach. One staff member explained they had become "less about knowing and more about doing" (YESM#4).

Although most staff members still said that Nano & Society conversations were important, the change in organizational goals put a stronger emphasis on tinkering and less focus

on demonstrations and using packaged activities. NISE Net materials, in general, were seen as not fitting with this new way of working with visitors. (See section B.4.3 for more details on YESM's evolving goals and misalignment with NISE Net.) One staff member explained that a drawback of the *Nano* exhibition and Nano & Society activities was that they required too much staff facilitation:

> I remember when the *Nano* exhibit opened . . . I remember one game, where everybody gets cards, and you go around and trade with people. Get different technologies and different applications. I thought that was enlightening. It was good. It was interesting and useful. It would be nice if that sort of deeper understanding could be worked into an exhibit that didn't require so much facilitation, because that was really . . . it had to be a led activity with a group of people for it to really have any meaning. (YESM#5)

NISE Net's reliance on staff facilitation to get its messages across was seen as not just labor intensive but also as out-of-date and misaligned with the more visitor-centered, curiosity-based approach. Moreover, losing the two staff members who were most familiar with the Nano & Society work further hindered the adoption of these new practices. As one individual on Site Visit 2 explained,

> The challenge is that [one person], who was trained [at the workshop], left within 6 months which is really too bad. And [the individual] who took her place, didn't have the training. And [the other individual] who also did the training, has left. So . . . there's probably too many people who know too little about what NISE Net means and how that influences us. (YESM#12).

This loss, combined with a general lack of enthusiasm for NISE Net because current staff members had only limited exposure to its offerings and messages, resulted in fewer conversations about societal and ethical implications during the second site visit at YESM. These factors seemed to create a sense of misalignment between the museum's work and the Nano & Society content and the conversational techniques encouraged by NISE Net. Data from Site Visit 2 point to how the earlier changes seen in staff members' and volunteers' interest to incorporate Nano & Society ideas into their work were short-lived due to revisions to the site's goals and the departure of key information brokers.

C.7.2 NEW ENGAGEMENT TECHNIQUES

Another area beyond nano content in which NISE Net provided partner museums with ideas and techniques was methods related to engaging staff members and visitors. At NISE Net gatherings and through various resources, Network Core Partners encouraged partner museums to adopt new training practices to engage staff members and visitors in different types of interactions. These techniques were included in a vast array of NISE Net offerings, such as NanoDays kits, online training videos, products from the Nano & Society Workshops, and the Nanotechnology and Society Guide. These resources provided tips and suggestions for how to better facilitate informal learning experiences with visitors. They also included methods for having open-ended conversations and using improvisation ("improv") as a way for staff and volunteers to build facilitation skills. During both site visits, there was evidence that this

information impacted individual staff members' work; however, long-lasting organizational changes were rare. In the following section, we describe how individuals and sites experienced change in these areas and why these effects may have been short-lived or limited to individuals, with little broader impact on the whole museum.

C.7.2.1 NISE Net provided museums with new staff engagement techniques that typically were used for just a short time.

Two of the main ways that NISE Net introduced new training and staff engagement techniques were through open-ended conversation strategies and improv activities. As described in the previous section, our sites were initially very interested in training staff to engage visitors in discussions around Nano & Society issues. Yet, this high level of enthusiasm was not sustained across site visits. A similar situation occurred in regards to the improv methods that NISE Net introduced as a way to build staff members' interpersonal skills and increase team bonding.

On Site Visit 1, staff members at several sites pointed to improv as a staff engagement technique they learned from NISE Net that transferred well to their settings. As described on the NISE Net website, "Improv exercises empower educators to facilitate positive, learning conversations with visitors. Incorporating improv exercises into staff and volunteer training helps create a supportive and upbeat environment for educators to practice and strengthen essential skills" (n.d.-c, para. 1).

Several staff members had been introduced to improv during the Nano & Society Workshop or through activities featured in the NanoDays kits and online library of resources. For these individuals, using improv was a new way to work with their staff and reflected a change in their practice. During Site Visit 1, one person from YESM told us that by participating in the Nano & Society Workshop he learned that improv "doesn't have to be overly scary all the time and it's not just for the acting students, we can do it in a group setting and be okay. . . [and] we started trying to use that especially with our volunteer coordinators" (YESM#9). Staff members at the City Museum & Science Center (CMSC) also talked about how positive the use of improv could be for their organization with one staff member saying,

> People forget that we can actually lean on each other, so those kind of improv activities I feel would benefit just, you know, staff in general as far as being able to talk and communicate, and kind of work with each other on how to engage the public or do a floor program, or even a paid programming. Just to have that support. (CMSC#2)

In general, during Site Visit 1 the introduction of improv into some of the museums' trainings seemed to have potential for organizational change in terms of how staff members engaged with each other.

However, by the time of Site Visit 2, the sites that had expressed initial excitement around improv as a training technique were using it less frequently. Although some staff members still credited NISE Net with teaching them this method and considered it something they could implement with staff someday, improv had not been fully ingrained into any of the sites' training practices. Sometimes this was due to staff departures or limited time for

implementing the activities. Even at CMSC where one staff member continued to try and "squeeze" the improv into her work with volunteers, she explained, "It's difficult when we are told we can only have so many hours of training and we have so much to get done." (CMSC#2) The case example below highlights how these barriers and others hindered improv from becoming a consistent feature of staff training at OSSC.

Case example: OSSC's difficulties incorporating improvisation into staff development

OSSC provides an example of how competing priorities, lack of time, staff turnover, and communication barriers can work against a new training technique becoming part of an organization, despite interest in it. At OSSC during Site Visit 1, several staff members mentioned that one of NISE Net's contributions to the organization was the improvisation ("improv") activities that had recently been added to monthly and daily meetings for part-time staff. At the monthly meetings, staff members typically learned about general museum updates, checked in about their work, and talked about areas that needed improvement. At the daily meetings, they reviewed the schedule for the day and everyone's tasks. After learning about improv at the Nano & Society Workshop, two of the education staff members started incorporating improv into these sessions to help the part-time employees improve their interactions with guests. One of the staff members who had attended the Nano & Society Workshop told us:

> We use a lot of their improv activities in training our part-time staff, which I had never even thought about until I went to some of the NISE Net workshops and they showed us some of those activities and how to facilitate them [which] really helped. (OSSC#1)

A part-time staff member seemed to appreciate the improv and how the activities got everyone ready for the day. She mentioned how

> we open up the meeting and we do a game that . . . kind of wakes you up because you have to be alert, and it kind of works on communication and remembering things that are fun. . . . I think the past two or three months we've started doing that and it's a really good way to open up the meeting because it gets everyone kind of in the chummy mood. . . . [and] gets your brain working. (OSSC#9)

Another part-time educator expressed similar thoughts:

> I have participated in, was it "Hydrogen, Hydrogen, Oxygen, Oxygen?" Ah, [two staff] brought it back from a conference they were at down in Houston . . . So they have been trying to get that in for all the [part-time educators] kind of as a way to get them energized and ready for the day. It kind of helps to get the blood flowing and also helps to get . . . us in a better state of mind so that we try to leave all the baggage at the door. So when we come in we're here to interact with the guests, we're here to have fun, and we're here to do a good job. (OSSC#10)

As these comments indicate, at the time of Site Visit 1, improv was integrated into the meeting schedule for floor staff. Both part-time and full-time staff talked about improv being a useful tool for improving communication with guests and each other.

Nonetheless, by Site Visit 2, improv was being used less frequently during the part-time staff meetings. Changes to the format, intended to facilitate cross-organizational information sharing, meant that other full-time staff members started attending, which left less time for improv. One staff member explained,

[Improv] kind of died off because . . . it's a good thing and a bad thing. Our full-time staff has started asking to come to meetings. So . . . for example, our last meeting, we had the Exhibits Team come in and [they] talked about some of the exhibit stuff that went on. The meeting before that, the Marketing Team came in and talked about a bunch of stuff. So, when we only have two hours, improv takes a while. And so when the full-time staff come in, sadly we have to cut that out. But when they don't, we still use it. (OSSC#1)

On Site Visit 1, cross-departmental communication had been seen as an area for improvement and was clearly something OSSC was still working on a few years later. Yet the solution of adding full-time staff members to a meeting previously for part-time staff meant less time could be devoted to facilitation activities such as improv. Thus, instead of being fully integrated into the meeting routine, competing organizational goals meant improv was not being used often, if at all, at OSSC.

Besides changes to the meeting structure, there had been turnover among staff members who had been involved in the improv activities on Site Visit 1. This included one of the full-time staff members who had been to a Nano & Society Workshop and some of the part-time employees who had taken part in the improv. Furthermore, the staff member currently managing the part-time employees was a relative new hire who was unfamiliar with much of the museum's NISE Net involvement or how improv had been introduced to the staff meetings. He thought "it was actually an idea from one of [the theater majors who works part-time] to do just a goofy improv and demonstration at each meeting to just make everybody relaxed" (OSSC#13). The connection to NISE Net and the instructional functions of improv seemed to have not fully transferred to the new staff member.

Although a few staff members during Site Visit 2 remembered the improv exercises, including the other employee who had attended the Nano & Society Workshop and at least one part-time staff member who had been at OSSC for several years, they were not in positions to lead the staff trainings and meetings. The part-time staff member recalled,

We haven't done any of those little improv games in a while . . . It was kind of like a team-building thing . . . because . . . when we work together, it's just go, go, go, go, go and we don't really get to interact with our co-workers and see who they are and stuff. It was kind of, just a team-building exercise. (OSSC#9)

However, even though some staff at OSSC remembered that improv had been beneficial for staff engagement, a range of contextual factors affected why this practice had not continued to the same extent. Chief among these factors were the changing meeting priorities that left no time for improv and a turnover in staff. Lack of communication about the previous role improv had played at trainings to the new manager also seemed to have an impact on why improv had not been sustained as a frequent practice at OSSC.

C.7.2.2 Visitor engagement techniques from NISE Net often changed the way individual staff members performed their work but rarely led to organization-wide changes.

In addition to introducing partner sites to new engagement methods to use with staff, Network Core Partners also provided NISE Net participants with many ideas related to visitors. Through kit materials—including instructions for delivering activities, main messages of each product, and useful talking points—NISE Net shared techniques for designing and delivering programs and activities. Moreover, professional development gatherings and additional website materials offered tips and suggestions for facilitating informal learning experiences. Yet, similar to many of the other practices discussed so far, this information seemed to have made an impact mainly on individual staff members without discernible long-term changes on the organization. The following section provides examples of where changes related to visitor engagement were seen at the sites we studied.

During both site visits, staff members from all six sites mentioned using approaches learned from NISE Net when engaging visitors in nano content. As one staff member said, "[NISE Net was] not about the stuff we get" but more about people "sharing tips, tricks, and tools . . . to communicate . . . about similar information" (CMSC#3). Some staff members also mentioned using visitor engagement techniques learned from NISE Net when creating programs and activities outside of nano. For example, when constructing other educational kits, several staff members explained that, like NISE Net, they started to include a facilitator sheet, have all necessary materials together in one box, and use a plastic information stand. When describing how NISE Net had been a useful example, one participant explained:

> So, you look at some of their pieces that they send you, and it helps. . . . On my tables now I'll put one of those plastic holders that we have. . . . Now I'll do it for other activities and other programs. I did not pick that up from other institutions. I actually picked it up from NISE Net. (CMSC#1)

Moreover, several staff members across sites commented that NISE Net changed the way they personally engage visitors by providing them with new and concrete presentation strategies. As one staff member at YESM recalled,

> Reading through the material, you know, "How to Present" thing like that, and a lot of the material had good information and it just kind of helps you reach that step of, "I can present this to the public," rather than just, "I'm showing this to the public and I don't want them to talk to me." (YESM#9)

A staff member from CMSC, when describing how NISE Net had impacted his own practice and the way he engaged visitors, mentioned:

> Originally I'm a teacher. I'm not an actor or a program presenter. . . . I go to a workshop, NISE Net does a great job of teaching me how to teach this stuff, right? And I go back, I feel more comfortable. I'm happy; I'm a better presenter. (CMSC#1)

Staff members at various sites also talked about gaining new examples from NISE Net for how to encourage inquiry learning. Although, inquiry learning was not a new concept for most staff members at the six sites, NISE Net provided fresh ideas about how to facilitate visitors

in an open-ended, exploratory investigation around a complex topic like nanotechnology. As one staff member from OSSC noted, NISE Net changed how she thought of this work:

> I already knew about inquiry-based learning, but they gave me more, I guess, techniques on how to engage guests that way. Because I mean you can teach guests things, but it's not always open-ended or creative and, I guess, NISE Net kind of helps with that . . . to let the guest explore what they know instead of us trying to teach them things. For example, the last NISE Net workshop we went to, they did an activity with the space elevator where kids could just draw what they thought the space elevator looked like and I was like, "That's nifty, I never even thought of that." Just letting kids do what they already know . . . and then you can add to that. (OSSC#1)

A staff member from PSSC echoed these sentiments about learning new techniques for engaging visitors in inquiry learning: "Asking questions . . . I think . . . was something that we've done before, but more so just asking questions and not trying to lead anyone to a specific answer. Just asking really broad questions just to get them thinking about things" (PSSC#1). Together these examples show how NISE Net led some staff members to change their own practices in terms of how they conveyed information to visitors. It seemed likely that because these individuals learned these practices, they would continue to use them for nano and other topics in the future.

Although this information was relevant and helpful to these individuals, there was little indication at the sites that these techniques were systematically shared with other staff members or incorporated into standardized training procedures. It was rare for staff to talk about how these ideas had been integrated into museum-wide practices or the mutual development of programs. Instead, they often talked about using these methods because of their own initiative. Without the spread of information or its formalization into any specific training or programmatic guides, there was little evidence that the practices introduced by NISE Net related to visitor engagement led to lasting changes at the organizational level. The following case example shows how NISE Net seems to have primarily influenced professionals' personal practice in this area. However, it also provides one of the only instances when a NISE Net technique related to visitor engagement become engrained within an organization's work.

Case example: OSSC's adoption of new visitor engagement practices and factors that supported and hindered this work

OSSC illustrates how NISE Net influenced individual staff member's practices in terms of engaging visitors. It also sheds light on some of the factors that can hinder and potentially support organizational change with respect to the adoption of these practices.

During Site Visit 1, both full-time and part-time staff members commented that they had learned new public engagement skills from NISE Net. These included how to better present information and converse with visitors. A staff member who had gone to a NISE Net gathering remembered picking up specific presentation techniques, such as what not to do when using PowerPoint slides:

> They got up and did a PowerPoint that had music with every, you know, slide change; it had funky slide changes; and it had lime green letters on a white background, you know,

and all this stuff. . . . Basically it was to teach us how not to do a presentation. . . . I love going to the workshops because it gives me information on nano, but it also gives me information on just how to work at this museum. . . . I mean all sorts of different things that don't even deal with nanotechnology. (OSSC#1)

A part-time staff member described how ideas from the cue cards in a NanoDays kit had changed her work: "I'm kind of an introvert so, the eye contact, and smile, and pay attention. Interact, ask them questions [were helpful suggestions]" (OSSC#9).

By Site Visit 2, OSSC was experiencing an increase in attendance, especially with school groups, that was affecting the responsibilities and work load of the part-time staff. The organization was understaffed in terms of floor educators and turnover had led to changes in who oversaw the part-time staff and how their meetings were run. With the loss of the individual who had gone to the Nano & Society Workshop and managed floor staff, not only was improv occurring less often but so too was the sharing of information about the nano activities and potentially useful visitor engagement techniques from NISE Net. In general, daily use of the nano activities at OSSC had dropped off.

Yet even though competing priorities, re-structured meetings, and staff turnover hindered the museum's overall use of nano and the widespread sharing of methods for engaging visitors, individual staff still referred to these practices. Indeed during interviews, staff members continued to mention ways that NISE Net materials affected their own practice. A few staff members specifically said that interacting with NISE Net materials on their own initiative had changed how they approach their work. During Site Visit 2, a part-time staff member who had earlier described benefiting from NISE Net's general facilitation techniques, made clear that she continued to use the information in a variety of situations:

Each of the little kits come with a "How to Interact with Guests" "Smile" and "Nod" [card] and I've actually taken a lot of what those cards said and applied it to everywhere from doing labs, interacting with kids on the floor, to teaching on Parent's Night Out. There's just good helpful hints on there . . . and it really did help and I think by now it's kind of become ingrained in my interaction with people. Even when I run into kids outside of here . . . and we kind of have a little conversation and I apply some of those there just subconsciously. (OSSC#9)

Another part-time staff member at OSSC also reported making lasting changes to how he interacted with visitors:

[NanoDays kits] showed me new ways to actually do some of my demonstrations because there's a set of guidelines in the NanoDays stuff and in my personal demonstrations with other sciences, you can pull some things from that and talk about that as well as you're doing something else. (OSSC#12)

Thus, even though there were fewer opportunities to use NISE Net materials with visitors or be trained in the facilitation techniques promoted by the Network, our results indicate that participation in NISE Net influenced individual staff member's visitor engagement practices.

Although data indicate that NISE Net primarily played a role in changing individual's engagement practices at OSSC, results also suggest factors that could lead to change on an

organizational level. During Site Visit 1, when information from NISE Net was shared more frequently, it was evident that the visitor engagement techniques were seen as useful ideas. One staff member, who had been to the Nano & Society Workshop, said he was able to come back with new suggestions for how to prepare the floor staff to interact with visitors:

> [Now I can provide part-time staff with] the tools to start a conversation with people so we don't have to tell them, "Just go out of the blue and start talking to people." [Instead, we can say] "No, have something in your hands that a child or even an adult can be like, "Hey, what's that?" or "Hey! Let me show you this" and get into [a conversation] like that. (OSSC#2)

By Site Visit 2, it appeared that the part-time staff members had started to request the kind of information that NISE Net provided with activity NanoDays kits also be included for other programming:

> I know of a couple of [part-time staff members] when they're doing different activities they really want that write up. They want to know what they're doing and why it's happening and what all it does and some questions asked and I think some of that comes from the little pamphlet that's in each box explaining what it is and it's good . . . and we obviously strive to try and have that for all of them. (OSSC#13)

The fact that multiple staff members were asking for the type of instructions NISE Net encouraged indicated that these ideas were spreading beyond individual staff members. With the formal documentation of information, considered by NISE Net to be useful for interactive, inquiry-based interactions, these techniques had the potential to become part of the larger organization's practice as well.

C.7.3 OTHER PRACTICES

In addition to adding Nano & Society content and new staff and visitor engagement techniques, NISE Net encouraged partner museums to adopt other practices not specifically linked to nano, such as using evaluation to assess the effectiveness of exhibits and programs and reaching out to diverse, underserved audiences. Network Core Partners sought to accomplish this by producing resources on evaluation and underserved audience groups, hosting gatherings and webinars devoted to these topics, and creating products that modeled universal design and bilingual practices. For evaluation, the Network Core Partners promoted a practice NISE Net had developed called Team-Based Inquiry (TBI), a "practical approach for empowering education professionals to get the data they need, when they need it, to improve their products and practices and, ultimately, more effectively engage public and professional audiences" (Pattison, Cohn, & Kollmann, 2014, p. 5). The Network Core Partners also developed guides about universal design, creating bilingual experiences, and the translation process, see section A.3.1.2. However, we saw only one instance of lasting change among the museums with respect to evaluation or practices related to universal design and underserved audiences. In this section we describe factors that appeared to stand in the way of organizational change in these practices. We also discuss the conditions that facilitated one museum's successful adoption of new practices regarding universal design.

C.7.3.1 Evaluation practices introduced by NISE Net did not change how organizations approached their work.

Among staff members at our six sites, there was general agreement that evaluation was important. However, there was variation in the extent to which sites were implementing this practice. At one end, staff members at YESM told us they had not done much with respect to evaluation; at most, they had put together a basic survey for teachers and performed minimal evaluation when developing exhibits. They engaged in this work occasionally, primarily to fulfill funding obligations. Staff at LPSC described more extensive evaluation efforts including general exit surveys for visitors, tailored surveys for specific teacher programs and camps, and small studies that involved local students. CMSC was perhaps the most active organization doing evaluation. Staff members and, at times, outside consultants collected programmatic feedback, conducted widespread exhibit prototyping, and administered a large scale survey to members, visitors, and people in the community.

Although almost all of the staff members we interviewed said evaluation was vital, they also felt their organizations were not doing as much as they should and that participation in NISE Net did little to change evaluation-related practices at their museums. Even for participants who were aware of the evaluation or TBI-related materials from NISE Net, factors such as a lack of time and not having the capacity to implement evaluation work hindered the adoption of this practice. In describing barriers to evaluation, a staff member said,

> One of my challenges here at YESM seems to be the evaluation component of our grant reporting and really wanting to beef that up, and personally being challenged at how to do that when there's so much fundraising that needs to happen, but also just seeing the industry has certain challenges in that area. . . . Trying to come up with the data to support what it is you're trying to say is very expensive and can be challenging. So anyways, the team inquiry was really helpful to look at ways we might be implementing evaluation on a smaller scale. We have not implemented it at all, as far as I can tell, which is mildly frustrating but mostly my fault! (YESM#12)

Another staff member at YESM explained,

> When I came on board, I got us set up with a non-profit Question Pro account to handle some visitor side evaluation. Given the pace of things around here . . . the time for proper, what I would consider evaluation, has to be kind of compromised. (YESM#14)

Likewise, a staff member from CMSC mentioned that she "hadn't really been using the Team Based Inquiry" but that

> it's something I let [another colleague] in on as far as, "It would be a really cool piece for you to implement into you floor staff." I just don't think she has really had the time to sit down and implement it. I haven't really changed our form of evaluation based on NISE Net [either]. (CMSC#2)

These examples indicate how the conditions at the sites often did not support the adoption of new evaluation practices.

Our analysis also indicates that a misalignment of goals may have factored into why study sites did not adopt new evaluation methods. Although NISE Net valued evaluation as a key means for improving one's work, evaluation was not always deemed a high priority at the partner museums. Even when evaluation was occurring, staff members often noted that it was a low priority compared to many of their other responsibilities, such as planning and delivering programs or other public offerings. As one staff member at PSSC described,

> Without having like a researcher or evaluation team or anything, it's just back burner. It's not ever been important with the exception of we put out evaluations for patrons to just evaluate, in general, our museum. It's not anything that's recorded or anything like that. (PSSC#1)

As discussed in Chapter 4 an alignment of goals is key for accomplishing organizational change. A misalignment of goals around evaluation meant that NISE Net had little influence over whether the six sites would adopt evaluation practices.

C.7.3.2 Except for one museum's use of universal design, practices from NISE Net related to reaching new audiences did not lead to lasting organizational change among the museums in our sample.

Similar to our findings with respect to evaluation, data indicate that NISE Net had little effect on organizational practices for reaching new or underserved audiences. During Site Visit 2, in particular, we asked staff members about how their organizations reached bilingual audiences, incorporated principles of universal design,[5] and tried to connect with adults and young children. We also asked how NISE Net may have had an effect on these efforts. Although almost everyone noted that reaching all of these audience groups was important and that they wanted them to be comfortable in their museums, most staff members indicated that NISE Net had not played much of a role in how their organizations approached this work. Although there was one instance of wide-spread and lasting change related to universal design, work related to bilingual practices typically involved using NISE Net's resources rather than adding additional languages to their exhibits or programs. While museums varied in how much they emphasized efforts to attract more adults and young children, NISE Net seemed to have little influence in these areas as well; therefore, we do not include those topics in the following analysis.

Reaching bilingual audiences

Even though most staff members at the six museums said they had local Spanish- or other non-English-speaking populations, overall, the sites were not offering many bilingual opportunities. The bilingual offerings they did provide were, for the most part, resources they

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[5] Universal design is the "design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (The Center for Universal Design, 1997, para. 1). "Universal design strives to create experiences that are accessible to users along a broad spectrum of ability—from able to disabled—to engage in a given task." (NISE Net, 2010, p. 4).

had received from NISE Net, such as NanoDays kit materials and the *Nano* exhibition. As a Senior Leader from YESM explained,

> One of the things that I've enjoyed immensely is having the *Nano* [exhibition] here and having bilingual labels because it says volumes when you have . . . [an] English-as-second-language family coming in . . . and [they can say,] "Oh, here are labels in my language" and it says a lot to them about the institution, "Okay, I am an honored part of this." Of course, the other side is–why aren't all the labels bilingual? We haven't gotten there yet. But, it certainly sets the standard very high for us. (YESM#1)

A staff member at OSSC described how, "at least in the kits, I liked that it had the bilingual thing which had Spanish in there and we had those dusted off for NanoDays and so they're useful" (OSSC#13). Another staff member at OSSC said, "I believe everything for *Nano* is bilingual. So that's been really great to have it in Spanish and English. . . . That exhibit's one of the few things we have right now that's bilingual, which is really nice" (OSSC#1).

However, even though staff members at several of the museums wanted to improve in this area, few credited NISE Net with helping them develop their own bilingual resources. Across the study sites, there was an overwhelming sense that even though NISE Net had provided bilingual products, the sites had not learned any specific information about how to do this work or changed their organizational philosophy toward providing multilingual offerings. Staff members seemed unaware of many of NISE Net's resources related to creating bilingual signs and programs and only a few mentioned that their work had altered to include multiple languages.

Instead, many staff members mentioned barriers that kept them from providing more bilingual offerings. These hurdles included a lack of skilled staff members, an absence of other resources, and a misalignment of goals. A staff member from CMSC noted,

> We don't do nearly as well as we should [with bilingual offerings]. . . . for us to hire someone to translate and do bilingual labels for all of our exhibits, since the vast majority of our exhibits are in house, is really expensive. So that's why we don't do that. We don't do that nearly as much as I wish we could. (CMSC#3)

Another CMSC staff member spoke about the misalignment of goals:

> And the bilingual community, I just don't feel it is the museum's focus at this point in time. I do see them working on label copy and potentially it could be something if they do another survey about demographics as far as who is coming to the museum and why or why not? If it's because we are not enough bilingual then maybe it might be the case that someone above us goes, "Well, then get on it." (CMSC#2)

Several staff members indicated that another barrier to adopting bilingual practices was figuring out how to present information to visitors in multiple languages. At a few sites, staff members were thinking of using iPads to convey this content:

> Yeah, that's one that we are working on— a technology program to set up an iPad kiosk and some large screens to be able to offer additional signage without it [multiple languages] being so overwhelming. Obviously, signage is tough in science centers, especially those with younger audiences. People don't want to read; just the volume of

text is overwhelming to some. So then if you double it to have everything in two languages [this would make the text even longer]. (PSSC#6)

It appears that many staff members faced a dilemma; although they appreciated the need to offer bilingual signage and programs, doing so was not a high priority of their organizations or jobs responsibilities, and they often lacked the necessary resources. As a consequence, we observed little long-lasting change in NISE Net's partner museums' bilingual practices.

Using principles of universal design

Likewise, when talking about reaching people with disabilities or incorporating universal design in order to be inclusive of the widest range of audiences possible, most staff members at the sites expressed that NISE Net had not affected their development of programs or exhibits in these ways. Generally, staff felt that NISE Net had not provided them with an adequate understanding of these areas or how they could overcome the barriers that made implementing these new practices difficult. In particular, when asked about whether or not they had learned anything from NISE Net about accommodating visitors with disabilities, most staff members said they hadn't. Some told us they remembered hearing about it but not much more: "I remember hearing about universal design, so I have learned some about it. It's just been, been a while. . . . It's one of those things that I haven't focused on, so after a while it kind of goes away" (OSSC#1).

It was evident that this information rarely went beyond individual staff members who had directly participated in NISE Net activities, and, overall, only a few staff members indicated they were aware of NISE Net's resources about universal design. PSSC, for example, was a site where the two main NISE Net brokers became more conscious of inclusive practices after taking part in Network events, but had not shared widely or made organizational changes. One of them explained how her work had been impacted after watching the Universal Design Webinar,

> Like I said, it's just interesting to kind of think of when you're writing these programs . . . for instance, we're obviously wheelchair accessible and I'm always trying to think about making our programs accessible for people in wheelchairs, but I never thought about things like, how if you ask . . . by a show of hands, repeating what you see for people who might not be able to see how many people have their hand up. (PSSC#1)

Similarly, the other PSSC staff member said,

> One of the things [my colleague] and I had wanted to do but have not gotten around to, and I can't promise we will any time soon, was to start offering, mornings where we would turn the lights down low for Autistic children and families to come in. We'd turn the lights down low and turn all the sounds off and stuff like that. And I remember [panelist at Universal Design Workshop] saying that, smells were a huge trigger for her. And thinking to myself, I bet, I know in our bathrooms the soap is scented. (PSSC#4)

Although it was apparent that the PSSC staff members had talked with each other and reflected on their own practice, they had yet to implement or formalize anything in a manner that would have an impact on the public or was likely to have a lasting effect on how the organization accomplished its work.

While our results indicate that NISE Net's efforts to encourage the adoption of universal design principles was limited among the museums we studied, the following case example shows how the right combination of factors led one museum to consistently apply principles of universal design as a result of their participation in NISE Net.

Case example: CMSC's application of universal design principles and conditions that facilitated these efforts

CMSC provides an example of how long-lasting organizational change may emerge around the practice of applying principles of universal design when the conditions are right, including an alignment of Network Core Partners' and partner museum's goals, the involvement of several staff members, and opportunities to implement new practices. In interviews conducted during Site Visit 1, information from NISE Net about universal design had resonated with several staff members. A few staff members at CMSC were already interested in making their museum more accessible to people with disabilities, and NISE Net's efforts aligned with this work. For example, two staff members had participated in an online webinar sponsored by the Network, and they made connections between NISE Net's work in this area and the universal design principles their organization was already trying to enact. As one individual said,

> I enjoyed learning about how to implement universal design better. . . . I think what I picked up mostly is that we are doing that here, we just hadn't been calling it universal design. So to . . . get a term with what you're doing is nice because then you can say, okay, this is how we can do better here. So yeah, to get a definition for what you were doing. (CMSC#1)

Another staff member pointed out,

> I do know that in programming, we do use the universal design. As far as making, you know, a base of what everybody has to walk away with, learning. And then, you know, obviously we provide more information for those who are able to kind of expand and take on that information. . . . I know they're looking at exhibits and working in a way [to think] about how they can make those more accessible to other age groups. (CMSC#2)

On Site Visit 2, when asking staff members about how they try to reach people with disabilities, several of them mentioned a range of efforts and noted that it was important for the museum. A Senior Leader stressed that they work with "a lot of organizations that serve handicap[ped] individuals and every year we have more than 12,000 visits from people who are either disabled or do not have the funds" (CMSC#12). Other examples of this work included connecting with associations of the blind and visually impaired, providing interpreters for people with hearing loss, and putting Braille and audio in exhibits. Staff members felt that being accessible to all visitors was essential because their city had a "huge population of adults with disabilities both physical and mental and it's a really supported community for that" (CMSC#13).

Although it was clear that accessibility was an area of emphasis for CMSC, during Site Visit 1 some staff members indicated they could do better. Involvement in NISE Net was seen as one way they were learning new techniques for how to do this work. By Site Visit 2, more staff

members had been introduced to NISE Net's universal design efforts and had applied the principles to their own projects. For instance, a different staff member at CMSC had taken part in NISE Net's Universal Design Workshop and was considered an advocate for universal design after she came back. This staff member, while familiar with universal design before going to the workshop, felt that

> the overall goal [is] making all educational programs more universally accessible especially considering the fact that I know where we lack in those areas. So trying to improve all the time and allow for groups that may be underserved to be able to use the space in a way that better serves them. (CMSC#14)

Although she was not always able to implement the changes she would have liked—due to being new at the museum, in a lower level position, and in a department outside of education—going to the workshop taught her "that it's not terribly difficult to make something accessible" (CMSC#14).

Even though she could not put in place all of her ideas, the staff member described two ways she had started to incorporate universal design principles into the work of the museum. The first related to a new exhibit project. For this work, she brought back thinking from the NISE Net Universal Design Workshop and shared information with exhibit developers. In doing so, this staff member tried to make the components "accessible to a wide variety of people" by stressing the need for closed captioning, having everything at the right height, and making sure to avoid sensory overload. She reported how several of these ideas were being implemented into their exhibit development process:

> I know that we had talked about some of this stuff . . . [we] do some closed captioning but it's not necessarily all over the museum and so the wheelchair height . . . I did bring that up because I wanted to make sure that it was addressed, and the tables that we have are actually wheelchair height so that seems to have been listened to. (CMSC#14)

In addition, this staff member had worked with another CMSC employee to update their training protocol for a new exhibit. The other staff member had attended a NISE Net regional meeting where information about universal design was also presented. As a result, both staff worked together to include information about interacting with visitors with disabilities to the training sessions for this new exhibit. Prior to Site Visit 2, the training had been held three times for floor staff, interns, and volunteers. Afterwards, some participants reported that they had already had to "handle these situations" and were "better equipped to truly give our visitors the best experience possible regardless of who they are" (CMSC#14).

Our interviews at CMSC indicate that NISE Net helped staff members integrate universal design into their programs, exhibits, and staff training. This work was able to occur because applying principles of universal design aligned well with the goals of the organization and multiple staff members and volunteers were able to learn about the topic and apply it to their own practice. As several staff members pointed out, NISE Net had given them ideas they could share with others through meetings, informal conversations, trainings, and, perhaps most importantly, as they collaborated to get work done, such as when creating a new exhibition. Overall, CMSC is a positive example of how information and practices promoted by NISE Net

can spread to many employees and become integrated into a museum's practices if certain conditions are in place, thereby leading to long-lasting organizational change.

C.7.4 SUMMARY

The findings in this chapter point to the difficulties organizations had implementing and sustaining new practices introduced by NISE Net. Among the museums we studied, we found great interest for many of the practices NISE Net introduced and promoted through a variety of means, including in-person meetings, web-based workshops, instructional guides and videos, and the distribution of materials that illustrated their use. These practices included incorporating new types of content—specifically about the societal and ethical implications of science—into exhibits and programs, new ways of engaging staff members and visitors, and new ways of using evaluation to improve exhibits and programs, reaching out to audiences through languages other than English, and applying principles of universal design to make their offerings accessible for everyone.

In most instances, enthusiasm about implementing these practices was high. This was especially true among the staff members we interviewed shortly after they attended a Nano & Society Workshop, where ideas about incorporating ethical issues about science and engaging visitors in open-ended conversations were introduced. The workshop also emphasized that staff members did not need to have all the answers to engage visitors in these discussions. Instead, it was possible to lead open-ended conversations that raised issues and encouraged visitors to think about their own values and opinions without possessing extraordinary levels of science expertise. These were new ways of working with visitors for most staff members, and they were excited to try them out; many also recognized that they could be applied to a wide range of science topics, not just nano.

Our analysis indicates several factors were associated with the initial interest for the practices introduced by NISE Net. Perhaps most importantly, these practices allowed museums to achieve their own goals. As described in Chapter 4, museums were always looking for new ways to engage their audiences, and the notion of talking about the values, risks, and ethics of science was innovative and especially exciting for them. Museums also saw evaluation as a way to improve their public offerings, and bilingual approaches and universal design as means of meeting their goals of expanding their audiences. In many cases, these were practices staff members told us they wanted to do and knew they should be doing, but had lacked.

NISE Net provided many resources to learn about these practices and guides for implementing them, although, as noted above, staff members often were unaware of them. Moreover, communities of practice (Chapter 1) are shaped not just by their resources but also by the constraints under which they do their work. Constraints in the museums we studied created barriers that worked against implementing and sustaining the practices NISE Net promoted, despite a desire to do so. Incorporating ideas about the societal costs and benefits of nano info programs and exhibits lost momentum due to factors such as the departure of key staff members who were strong advocates, a reluctance to try new things, and a mismatch with the school curriculum. The use of improv, a new engagement techniques for staff members, was hindered by something as prosaic as a lack of time due to a change in the structure of staff meetings.

Museums' efforts to incorporate bilingual practices and principles of universal design were often hindered by a lack of knowledge and the fact that these areas were not top institutional priorities. In many instances, these factors interacted in ways that that made adoption of a new practice especially unlikely: the loss of a strong advocate for a new practice made it especially difficult to overcome institutional hesitancy to try new things.

The incorporation of universal design principles into CMSC's exhibition design process is a positive counterpoint that supports our analysis. The appropriate conditions can facilitate the adoption of new practices. In this case, increasing public access was already an important goal of many staff members at CMSC, including senior leaders, and resources were made available to implement this work. Staff sought out relevant information from NISE Net and shared what they learned within the context of joint work so that it could be put to use quickly. NISE Net was instrumental in providing ideas and details about accessible approaches but the motivation and methods for implementing them were made possible by CMSC's community of practice.

CHAPTER 8. CHANGES IN STUDY MUSEUMS' PARTNERSHIPS WITH LOCAL SCIENTISTS

As mentioned when describing the Network Core Partners as a community of practice (Chapter 1), collaborations between scientists and museum professionals were one of several additional areas of work encouraged by NISE Net. Staff members at the museums we studied discussed multiple ways that partnerships focused on nano content came about and said that this often reflected a change in their organizations' practice. Before joining NISE Net, only one museum had nano-related partnerships with local scientists. After involvement in the Network, three of the study museums had partnered with nano researchers. This work varied; university scientists sometimes sought to work with museums on nano exhibits to fulfill the "broader outreach" requirements of NSF grants, at other times, museums invited local nano scientists to present their research as part of their youth or adult programming. NanoDays events, in particular, emerged as an especially productive source of scientist-museum partnerships.

C.8.1 NANODAYS EVENTS AS A CATALYST FOR PARTNERSHIPS

Through NanoDays, the Network's signature event for the public, NISE Net emphasized the importance of scientist-museum partnerships. The Network Core Partners framed NanoDays as an event to "bring university researchers together with science educators to create learning experiences for both children and adults to explore the miniscule world of atoms, molecules, and nanoscale forces" (NISE Net, 2014b, p. 22). As presented in the 2015 NanoDays Planning Guide, NISE Net suggested partner museums

> collaborate with at least one other institution in [the] community to plan and conduct [a] NanoDays event. Partnerships among informal science educators, scientists, and engineers can provide [the] event with your combined expertise: a sophisticated understanding of how to engage the public, as well as a deep background in the science and technology of nano. (p. 10)

The Planning Guide included ideas for finding collaborators and links to two additional guides developed by NISE Net about starting and sustaining partnerships.[6]

Findings from this study indicate that NanoDays events were, indeed, a factor that led museums to develop partnerships with nano scientists in their communities, resulting in changes to practice. But, in the case of one museum we studied, this was only a short-lived change. We present information about these partnerships in more detail below and discuss some of the common conditions that facilitated and hindered their formation and sustainability.

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[6] See "A Guide to Building Partnerships Between Science Museums and University-Based Research Centers" (Alpert, 2013) and "Bringing Nano to the Public: A Collaboration Opportunity for Researchers and Museums" (Crone, 2006).

C.8.1.1 NanoDays events were a catalyst for museums and outside scientist or industry partners to connect.

At three of the six sites in this study, NanoDays events were a catalyst for forming collaborations with nearby nano experts. In total, across the three sites, there were five different partnerships related to NanoDays events. Responses from both scientist partners and museum staff members at these sites highlighted how NanoDays events provided opportunities to begin or deepen connections. Even at the museum where the collaboration ended after a brief amount of time, the relationship reflected a short-lived change in how the organization worked with an outside scientist and engaged the public in nano. For the other two sites, the partnerships initiated by NanoDays events were expected to continue into the future and reflected long-lasting changes in the museums' work.

When asked about how partnerships connected with NanoDays began, museum staff explained they were sometimes initiated by outside scientist or industry partners eager to participate in the event. For example, a scientist who had heard about NISE Net and NanoDays events through involvement in the Materials Research Society described contacting his local museum:

> I was looking for a partner to do this [NanoDays event] with basically [laughs]. And one of my colleagues had some interaction with them and gave me a name of someone to call down there. So I just kind of cold-called them and we went from there. (LPSC#15)

A museum staff member at the Local Partners Science Center (LPSC) also remembered that the scientist had "initiated the conversation and said [to the museum], 'Do you want to do this?' . . . And we asked him a little bit more about it and then we said 'sure!'" (LPSC#5).

Alternatively, one of the NanoDays partnerships for the City Museum & Science Center (CMSC) started because of museum staff wanting to expand the event. The scientist described how the museum made initial contact regarding a potential collaboration. As the scientist partner recalled,

> So I was reached out to by . . . I forget the gentleman's name, but he had been one of the program directors or managers . . . and asked if someone from our company would be interested in helping or demonstrating. So we used some of the NISE Net demo kits, basically [facilitated] those at a couple of tables and we also had a small informational thing about how we use nano materials and making products and actually manufacturing those in [city name]. (CMSC#16)

There was also evidence of a NanoDays event partnership that built off of previous work. At the Outreach & School-focused Science Center (OSSC), for instance, a scientist who had been active on the site's Board had her first experience taking part in a museum offering during a NanoDays event. As she said, "[O]ur first big thing that we did that I ever participated in as far as programming goes for the [Science] Center was the first NanoDays that was a NISE project" (OSSC#16). Similarly, a museum staff member explained that until involvement with NISE Net, the organization had not realized it "could actually have [this scientist] doing demonstrations here. We were like 'oh, you did this for a living, we should use this!' Yeah, we never actually

thought about having her do any kind of demonstrations or anything until NISE Net" (OSSC#1). In this case, data indicate how a NanoDays event provided both the motivation and the opportunity to invite a scientist partner already connected with the museum to become more involved in the visitor-related work of the organization.

Together all of these examples underscore how NanoDays events were often the reason why museums started or deepened their work with a nano scientist. This reflected a change in not only who the museum connected with in their community but also how they presented nano to their audiences.

C.8.1.2 Partnerships around NanoDays were facilitated by shared goals and mutually beneficial work, as well as the fact that the event was an annual occurrence.

At the sites where NanoDays events served as a key impetus for partnering, three primary facilitating factors emerged. Although the five distinct museum/scientist NanoDays event partnerships started in different ways, it was clear that an alignment of museum and partner goals was essential for this work. Moreover, both parties needed to benefit from this collaboration, and the annual nature of the NanoDays events enabled the partners to stay in touch. Each of these factors and how they played a role in the partnerships at the three sites are described below.

Shared goals

As mentioned in Chapter 4, our museums had aims that were specific to their organizations, such as encouraging students to pursue local STEM careers or inspiring curiosity-based learning through open-ended activities. However, across all the museums there were commonalities in wanting to provide visitors with an educational, interactive, and fun science experience. Another important goal for the museums was a commitment to having strong connections with their communities and schools. Furthermore, sites emphasized wanting to broaden their audiences and to be more STEM-focused.

When scientist and industry partners described their goals for collaborating, there was often alignment between the reasons they gave for doing this work and some of the common museum objectives. As one scientist who partnered with OSSC said, "I wanted to be able to connect with the community on the importance of the kind of research that we're doing. . . . I think that it's important to educate . . . and [another goal was] getting to work with kids" (OSSC#16). A scientist partner from CMSC noted one of his reasons for connecting with the museum was tied to reaching a larger public: "Because we are now trying to achieve the goal of spreading the nanoscience education, you know, by having a bigger audience" (CMSC#11). A different scientist who was involved in the NanoDays events at CMSC also reiterated how useful he felt it was for young students to see "what types of research professors do and learn that nanomaterials are not just scary, but at the same time not necessarily going to cure all cancers tomorrow" (CMSC#16).

These comments indicate how scientists' goals for participating in NanoDays events were in strong alignment with museums' aims. Partnering around this event helped both scientists and

museums educate visitors about the specific field of nano science, reach broader audiences, and make local connections in the science community.

Mutually beneficial

A second factor that supported NanoDays event partnerships was that scientists and museums found the relationships to be mutually beneficial. Researchers and industry partners commented on how they gained communication skills by helping facilitate the event and share their work with the public. As one scientist partner exclaimed,

> I'm telling you I picked up so many . . . even just phrases from those activities that I still use today. I talk to students and teachers . . . and I'm still telling them that when you take a material to the nanoscale you change the physical properties. The materials even become a different color. I remember getting that from the experiments that we were doing that day, but people can connect to that, right? They can think, "Oh wow, changes the color of gold!" or "changes the color of silver" and it at least gives them some point of connection for what we're gonna talk about next. (OSSC#16)

Not only did researchers feel they benefited from working with the museums, but sometimes they commented on how their students, who also attended the event and demoed the activities, grew from these experiences as well. A scientist who partnered with CMSC for NanoDays events said,

> I think that it's beneficial to get students interested in science by people that do science. I like seeing my undergraduates from my lab go in and talk to students that are 10 years younger than them and I think it motivates them and also gets them excited also about science by explaining it to others. (CMSC#16)

One scientist who worked with LPSC, reflecting on how the NanoDays event partnership was valuable to both parties, noted,

> So what they offer me is an audience, they have a terrific way of reaching out to people in the [local area] and advertising it. . . . Another really important thing that they offer is their expertise in how to work with the public and how to design activities to make them effective for the public, especially at a certain age group. . . . that I've passed on to our [college] students . . . I'd like to think that we've provided them with some expertise and some willing participants . . . [that the Science Center] would not have access to this group of people, you know, my undergrads [without this partnership] . . . this gives us a chance to bring some of our expertise out of the laboratory and into the public eye. (LPSC#15)

Indeed, staff at LPSC agreed that they, too, benefited from this collaboration in several ways. As one employee on Site Visit 1 described, she's gained "some great connections—networking that I still use for things other than nano [as well]" (LPSC#5). She also went on to mention how staffing at their museum can be an issue but that "it's easy to make [NanoDays events] big because of the amount of supplies we get and the support we [get because the outside partner brings] . . . so many people to do it, 'cause they're so into it, too" (LPSC#5). On Site Visit 2, a different staff member felt the continued work with this scientist partner helped LPSC:

> Our goal here is to get kids excited about careers and get them ready. . . . So where the scientists or technicians or these real world workers come in is, like, the theory that if you don't see it, you won't be able to aspire to that or know how to do that." (LPSC#2)

Examples from this site show how NanoDays events offered both sides of the scientist/museum partnerships valuable experiences.

Annual occurrence

Besides overlapping goals and jointly beneficial work, a third factor facilitating these partnerships was having regularly occurring events. NanoDays celebrations, in particular, served as a reminder and check-in point in this way. In many instances, connecting for NanoDays events became a recurring instance of partnering for sites in this study. As one scientist partner reported about NanoDays, "by having a specific weekend . . . that creates a nice time point that forces us to reconnect each year" (CMSC#16). A different scientist partner mentioned how

> we've done a couple of things over the last few years—all of them were really motivated by the existence of NISE Net and the NanoDays week of outreach activities. So, that has been . . . that was both the motivating factor and it has been the stimulus for my continued involvement with the Center. It's the thing that reminds us annually that we should get together and do something. (LPSC#15)

A staff member at LPSC similarly felt that the annual format was good because

> it enables us to have this goal with our partners, like we know every year we're going to do this particular project together. Whereas if you left it up to us and there was no date you might put it off or not do it a consistent time of the year. (LPSC#2)

Because NanoDays was a repeating yearly event, it made it easy for partners to stay in touch and continue working with one another. These examples highlight how NanoDays often led to lasting changes at the museums because they maintained connections with scientist partners that recurred each spring.

C.8.1.3 Difficulties in NanoDays event partnerships centered on staff turnover and communication barriers.

Although some partnerships that began with NanoDays events were very stable and even expanded over the years to include collaborations around other programs, there were instances in which barriers arose. The case example below shows how two of CMSC's NanoDays event partnerships were maintained over several years and the scientist partners participated in additional guest lectures. Yet this section describes two of the main factors that affected scientist/museum partners at our sites: staff turnover and communication difficulties. Both museum staff and scientist partners talked about how these areas either had or potentially could play a role in the lasting nature of their relationships.

Staff turnover

At all three sites where there were partnerships related to NanoDays events, there were also changes in museum staff. This turnover contributed to the ending of one partnership and the stalling of another. In the third instance, although the relationship had already endured staff changes and continued to be long-lasting, the scientist partner said that any further turnover might lead to future difficulties. Examples from these sites underscored how it could be challenging, but not necessarily impossible, to sustain connections when people left jobs or changed responsibilities.

Staffing changes hindered partnerships because it was often difficult to transfer the associated personal connections to someone else. In the case of the partnership that was short-lived, the scientist attributed much of the collaboration to the working relationship she had with the staff member who moved on from OSSC. The scientist partner said,

> When [the staff member] left and my time on the board was up . . . they hired [someone else]…and I haven't connected with him. I haven't done it in a couple years since he came. I mean I haven't even met him ever. So it was really my involvement was built on my relationship with [the first individual]. (OSSC#16)

Similarly in looking ahead to future instances of partnering, a scientist at LPSC worried about having someone to reach out to if more staff transitions occurred. Despite seeing benefits of having only one point person at a time, he explained "Now I have to say, if [the museum contact] disappears, there isn't an obvious next person for me to connect to . . . if she were to depart . . . I would lose my strong connection there" (LPSC#15).

Although staff transitions also occurred at CMSC, this site provided an example of a partnership that continued even when hindering factors arose. At this site, after the initial contact person left, there was a period of time when the museum and the nano scientist partner lost touch. Even though the departing staff member had suggested names for the scientist to reach out to, the partnership stalled and it wasn't until a NISE Net meeting that both sides reconnected and started thinking about the next NanoDays event. While the scientist partner said he "miss[ed]" the initial contact person "because [he] was very good in understanding our needs and, you know, trying to arrange [the NanoDays event.]" The scientist partner also felt that their new contact had "responded very positively for this year's [NanoDays] activity" (CMSC#11). Thus, even though this partnership had to wait a while to reform, the impetus of a NanoDays event seemed to have been key in allowing this organization and outside partner to continue working together despite going through staff turnover.

Communication barriers

Museum employees and nano scientist partners both felt strong communication was crucial for sustaining long-lasting partnerships. In the one instance of a short-lived NanoDays event partnership, a lack of communication certainly hindered this work. For the ongoing collaborations, communication issues were perceived as possible barriers. Thus, as was seen with staff transition, communication obstacles, both real and anticipated, had the potential to interfere with partnerships.

Although staff changes played a role in ending the short-lived partnership between OSSC and their nano scientist partner, communication difficulties were also present. In this case, while both the museum and scientist partner wanted to continue working together, there was trouble connecting the scientist with the right staff member after the initial contact left. The scientist partner explained that "when the new [staff member] came in, I called him a couple times and left messages and [I didn't get a response]" (OSSC#16). However, a museum representative, in describing why the partnership had ended, also said, "We tried to contact [the scientist] and just could not get ahold of her" (OSSC#1). Here, it appears that both sides were trying to reach each other but were running into communication issues.

In looking ahead to future work, several scientists in partnership with CMSC felt that good communication would always be necessary. When reflecting on this topic, one scientist partner mentioned, "I think in general people are very bad at communication and just having regular periodic checkups" (CMSC#16). Another scientist reiterated how a sustained partnership "requires probably periodic meetings" (CMSC#11). Museum staff agreed it was critical for interaction to happen throughout the course of the year in order to continue the collaboration. One staff member when talking about how frequent communication was necessary noted,

> NISE Net really put it in place that partnerships need to [be] created and sustained. That's just something that I've tried to keep in contact with them throughout the year, even when NanoDays isn't happening. Just a "hey, what's up? Just wanted to drop a note." Just keeping those partnerships alive so that they are more willing and want to come back and they don't just feel like I used them for a day and that's it. (CMSC#2)

As can be seen, both museum employees, scientist partners, and even NISE Net recognized how the extent of communication can affect whether or not a partnership continues long-term.

Case example: CMSC's partnerships that grew out of NanoDays events

CMSC is an example of a site that had multiple partnerships develop because of NanoDays events. In one instance, as described above, staff changes led the work of this partnership to pause for a while, however other NanoDays event connections evolved to include other projects over time. The following section gives insight into how NanoDays event collaborations aligned with CMSC's work and benefited both the organization and the scientist partners. These partnerships were examples of long-lasting change that came about as a result of RSMC's participation in NISE Net.

While involvement in NanoDays events encouraged connections with nano scientists, CMSC had several non-nano partnerships as well. Collaborations, in general, were considered to be very important for the museum, especially ones that connected the organization with the local science community including regional universities, science societies, companies, and education-based groups. One staff member said that partners were important from the "floor perspective" because "it provides public speakers, special event opportunities, it keeps myself and other staff constantly learning and keeping the excitement as well" (CMSC#13). A Senior Leader of the organization described how useful it was working with groups that could introduce them to new audiences and how partnering with researchers, in particular, "can tell you what's going on"

(CMSC#12). Indeed, this museum had a history of hosting weekend events in which outside members and groups from the scientific community could come and present their work to the public. This site also had partnerships with other science centers across the country.

The three partnerships connected with NanoDays events at CMSC each started in a different way and reflected new collaborations. One had been initiated by the museum, one by a scientist partner, and the third due to mutual engagement in NanoDays celebrations. The partnership started by the museum grew to involve even more members of the local science community after the scientist partner pulled in several of his connections. The scientist partner, who worked in the nano industry and gotten in touch with the museum, explained that he had seen marketing for the event and

> thought it was interesting, and then my wife said, "Your stuff should be over there as well." And I said, "Well . . ." I didn't think about that because I never thought about exhibiting my stuff in a museum! So I contacted [a museum staff member] and said, "This is what I'm doing. Would it be something that would fit into your curriculum program with nanotechnology?" And she said, "Absolutely!" (CMSC#15)

The third example of a nano partnership started after a different scientist "found there was a drop in the number of participants coming in from schools [to their NanoDays event]" at a local university (CMSC#11). Soon after, the museum and this individual started to collaborate.

Although each relationship started under a different circumstance, in general, the partners performed similar work at NanoDays events, which involved talking about nano science and presenting some of their own work. Two of the three scientist partners mentioned using the NanoDays kits during the events. One of them reported, "we typically bring some research demos from our academic labs and then also use some of the NISE Net demos" (CMSC#16). The other scientist, who was an industry partner, seemed to primarily use his own products during NanoDays events.

All the scientist partners talked broadly about how volunteering in this way helped them achieve their own goals. As one described, "It is a greater opportunity to publicize nano materials and nanoscience." (CMSC#11). Another said:

> What I'm trying to accomplish is the spread of NanoDays to a larger audience . . . the great impact of the museum is that . . . when they send a message that we are having an exhibition to schools, the school children will be brought in in busloads. They don't have any limitations to that activity, but if I tell them to bring them to [my university] as I was doing in the beginning, now the budget and everything comes in. (CMSC#11)

The third scientist partner echoed these sentiments, saying, "in terms of my own personal goals . . . the easy goal that it satisfies is that I'm helping the kids" (CMSC#15).

Overall, the scientists also felt that CMSC benefited from their joint work. One scientist partner believed the museum gained real world examples by collaborating with scientists:

> Their charter is to promote intellectual curiosity in the natural world. I'm sure they would like to hook up with technology companies and find out what the practical applications are for science and trends and link them to practical applications in the real world which I can certainly do and I can see how I can help the museum achieve that goal. (CMSC#15)

Likewise, staff from the museum indicated that the partnerships were useful because of the value added to the programming: "It's not just a floor staff person that's kind of talking at you. It is someone outside . . . who is excited to be at the museum . . . delivering this kind of facilitated program" (CMSC#2). In reflecting further on what the museum obtained from these connections, this staff member continued to say that it can be helpful to mention the partnerships to others:

> If an executive is talking with someone else about, "oh yeah we work with [name of business] it's a nano company in [city]." It might kind of create a snow ball effect for other people to want to join in. (CMSC#2)

Another staff member felt that partnering around NanoDays events helped "engage the audience in STEM content, getting them excited about opportunities in science, the research going on locally is a big deal, we want to be able to highlight local research as best as we can." (CMSC#3)

Although staff turnover at CMSC had caused one of these partnerships to slow-down for a time and communication was always viewed as a potential barrier, two of the partnerships expanded to other areas. By Site Visit 2, these partners had given additional presentations at the museum's nano summer camp and were considering further areas of work. One scientist partner had even volunteered to host campers at his lab. In describing why he offered this opportunity, he reported,

> As long as it's not a full week of students in my facilities here then I can certainly host people for half a day, it's not that much effort. And the students in my lab enjoy doing it. I think it's good for them to practice science outreach and science communication. (CMSC#16)

As can be seen through these examples, NISE Net and NanoDays events played a key role in starting partnerships at CMSC with nano scientists. CMSC's evolving partnerships provide evidence of how collaborations initiated for NanoDays celebrations can lead to long-lasting changes at an organization. While partnering was not a new concept for the organization, these partnerships significantly affected the nano public programming and additional camp-related offerings. Both museum staff and scientist partners attributed these connections to NISE Net and felt the partnerships would be long-lasing because they accomplished mutual goals and were viewed as beneficial.

C.8.2 SUMMARY

Overall, data point to how partnering related to NanoDays events was a change in practice for three museums in this study. Participating in NISE Net allowed these organizations to begin or to expand relationships with nano scientist and industry partners. Not only did Network resources and guides offer suggestions and tips for partnering, but the yearly NanoDays event offered a specific reason to connect.

Prior to hosting a NanoDays event, it was rare for the museums in this study to have partnerships with nano scientists in order to engage the public. While these partnerships were initiated in a variety of ways—either by the scientist, the museum or because of existing work— they all resulted in opportunities for visitors to interact with nano researchers. At two of the three

sites, the newly created partnerships were expected to be examples of lasting change in terms of how museums worked with outside individuals and presented information to visitors.

Factors that supported this work included the overall alignment between museums' and scientist partners' goals to create and offer educational experiences about nano, reach larger audiences, and make connections with other local groups. Moreover, both sides felt this work was mutually beneficial. Museums described the gains in terms of being able to offer visitors meaningful interactions with scientists while nano researchers talked about the enhanced presentation skills and opportunity to share their work with the public. Through NanoDays, there was also a clearly defined reoccurring event that brought partners together.

Conditions that interfered with long-term partnerships included staff turnover and communication barriers. When staff left the museums, it was often challenging to rebuild or transfer the prior personal relationships. If staff changed and new channels of communication were not set-up, then collaborations could wane or stop all together. Even with NISE Net's encouragement to have ongoing communication throughout the year, real or anticipated lapses in contact arose as an issue for lasting relationships.

It is important to note that a combination of these factors was often present with NanoDays event partnerships. Typically, no one aspect facilitated or hindered the ongoing nature of the relationship, but a mixture of issues came into play. These factors reflected the conditions and constraints of each community of practice. Moreover, they underscored areas where NISE Net was often able to support the museums in creating or expanding their practice of partnering with nano scientists.

As was seen, CMSC was a site where both facilitating and hindering factors were present in regards to their NanoDays event collaborations. There was alignment between the CMSC and their partners' goals in terms of wanting to offer fun, educational events, and NanoDays provided a way to come together to accomplish these mutual aims (Chapter 4). Certainly, the annual nature of the event facilitated the flow of information between NISE Net, CMSC, and the scientist partners (Chapter 5). When staff transitions took place, NISE Net aided the continuation of one partnership because museum staff and the scientist were able to reconnect at a Network gathering and start planning for the next NanoDays event. In this way, NanoDays events supported CMSC's efforts to convey nano to the public and helped create long-term collaborations with outside partners. Due to NISE Net, the practice of partnering around nano started to become embedded in the organization's work and was even incorporated into other programs as well.

PART D: SUMMARY AND CONCLUSION

Part D offers a summary of the project and our findings, and a concluding discussion (Chapter 9). By summarizing the conditions that facilitated organizational change and the barriers that hindered it, this chapter makes connections for future research and other projects.

CHAPTER 9. CONCLUDING DISCUSSION

D.9.1 SUMMARY OF STUDY

The NISE Network provided a unique opportunity to look at how informal science education organizations experience change due to participation in an outside network. NISE Net, with its impressive national reach, exposed over 500 organizations by its 10th year to new ideas, techniques, and products. Besides NanoDays kit activities, exhibits, and other freely available materials, the Network offered partners a range of professional development opportunities to enhance both nano and non-nano-related work (Chapter 3). By studying how a group of museums adapted and modified their practices because of participating in the NISE Net, this research was able to look at how networks could promote organizational change among ISEs and at what factors affected this process.

This study employed qualitative methods to conduct longitudinal case studies of six, highly involved NISE Net museums (Chapter 2). In doing so, we were able to observe change in terms of how these NISE Net partner organizations performed their work; how new and revised practices, goals, and values become ingrained in their efforts; and how these new areas of knowledge and practice spread beyond just one individual to influence the staff at large. Site visits, separated by 18-20 months, allowed us to see changes that had a short-lived lifespan (i.e. were abandoned before the second site visit) as well as those that looked as if they would be sustained over a longer period of time because they had already lasted several years. We collected data through a variety of methods including interviews with staff members, volunteers, and scientist partners; onsite observations of meetings and programs; and online surveys of staff members. Thus, we gained a rich sense of how each site functioned as a community; how each of the six sites received, interpreted, and used information from NISE Net; and how this work changed over time. By coding, first for themes at individual organizations and then for trends across the organizations, we learned about the types of changes that museums experienced as a result of their participation in NISE Net and about conditions that facilitated and hindered these changes.

The communities of practice framework developed by Etienne Wenger guided our efforts (1998a; Lave & Wenger, 1991). Wenger's approach emphasizes how change can result from the interaction between organizations with distinct but overlapping histories, values, goals, and practices (Chapter 1). In our case, we considered NISE Net and each of the participating museums to be a distinct community of practice because each had its own forms of joint enterprise, mutual engagement, and shared repertoires (Chapter 3). In other words, each had its own set of goals that the entire staff was working towards (i.e. joint enterprise), similar practices and tasks (i.e. mutual engagement), and a common pool of resources (i.e. shared repertoire). Because the communities of practice framework specifically focuses on how organizational learning occurs among a group of people who have a collective purpose and are working together to accomplish these goals, it provided a useful lens for considering whether and why organizational change may have occurred at the six museums due to participating in NISE Net. In addition, this study considered how information from the Network flowed to and within the museums and whether there was alignment of goals between the six museums and NISE Net

(Chapters 4 and 5). This framing was important for understanding the types of changes occurring within and across the museum communities.

D.9.2 OVERARCHING RESEARCH FINDINGS

D.9.2.1 Involvement in NISE Net affected organizations' work including their public nano offerings, practices unrelated to nano content, and partnerships with local scientists.

Overall, this research clearly indicates that taking part in a network impacted the practices of the six organizations studied. Specifically, by participating in the NISE Network, the museums made changes to their public nano offerings, to their practices unrelated to nano content, and to their partnerships with local scientists. What follows below is a brief summary of the types of changes that were seen in these three areas and a description of the contributing factors. While these changes were not all necessarily long-lasting, they show that participating in a network can affect an organization's work in a variety of ways.

Changes in the museums' public nano offerings

Before joining NISE Net, most of the organizations in this study had no nano-related offerings. With the help of the Network's resources, all of the museums added new or additional nano exhibits and activities that represented a significant change in the museums' public efforts (Chapter 6). Findings suggest that one of the main ways that NISE Net increased the museums' nano-related offerings was by providing the *Nano* exhibition. Participating in NISE Net also led some museums to develop their own exhibits with nano content. Overall, the data indicate that new nano exhibits often reflected a long-term change in the organizations' practices. Not only were these exhibits typically on display for extensive periods, enabling the museums to reach many visitors with this content, but they were expected to be on view for several years to come. The nano-related exhibits were generally not vulnerable to programmatic barriers such as modifications to museum schedules or staff availability. Further, the *Nano* exhibition often led to sustained change because *Nano* had few barriers to public engagement thus allowing museums to meet their organizational goals of providing new opportunities for visitors to interact with up-to-date STEM content.

Besides adding nano-related exhibits, the six museums involved in the Network increased their nano programming. The NanoDays kit materials supplied by NISE Net were particularly useful in this regard. The NanoDays kits aligned with many of the museums' existing hands-on activities, adapted easily, and required little staff training. The NanoDays kits were not only used during the Network's annual NanoDays celebrations, but also throughout the year for a wide range of programming experiences both on- and off-site. While the research suggests that engaging in nano programming was certainly a change for the museums in this study, it was not necessarily long-lasting. Programs were susceptible to shifting museum goals and to changing exhibits. Programs were also vulnerable, unlike nano-related exhibits, to staff transitions or busy schedules. Other factors including spacing constraints or wavering visitor interest also came into play. These reasons contributed to the fact that the increased level of nano programming was

generally short-lived, even though some museums planned to continue using the NanoDays kits and nano in their offerings.

Changes in the museums' practices unrelated to nano content

In addition to introducing nano content into exhibits and programs at partner museums, NISE Net encouraged museums to adopt practices that were not specifically related to nano (Chapter 7). For instance, NISE Net recommended museums engage visitors and staff in new ways, such as through conversations related to the societal costs and benefits of science or through improvisational exercises that would build interpersonal skills. They also suggested that partner museums employ universal design principles in their work to make public experiences accessible for all visitors, that they provide bilingual programming and exhibit text, and that they consider gathering evaluation feedback.

Although the museums in this study often greeted these new strategies with great eagerness, and although NISE Net modeled new practices and provided training and resources to help museums with this work, we rarely observed long-lasting organizational changes in these areas. Despite the museums' desire to implement and sustain the practices NISE Net promoted, there were often barriers to this work. Incorporating ideas about societal costs and benefits of nano into programs and exhibits lost momentum due to factors such as the departure of key staff members who were strong advocates, a reluctance to try new things, and a mismatch with the school curriculum. The long-term use by staff members of new engagement techniques was hindered when they lacked sufficient time to regularly continue this work. The inclusion of bilingual practices or evaluation was often affected by institutional priorities and by staff members' lack of familiarity with these topics.

However, data from one organization suggest that the appropriate conditions can facilitate the long-lasting adoption of new practices unrelated to nano. At this museum, NISE Net helped staff members integrate universal design into their programs, exhibits, and trainings. Here ideas related to universal design aligned well with the goals of the organization and were shared with staff and volunteers through meetings, informal conversations, trainings, and, perhaps most importantly, through collaborative work such as creating a new exhibit. This organization provided an example of how information and practices promoted by NISE Net can spread to many employees and become integrated into a museum's work if certain conditions are in place.

Changes in the museums' partnerships with local scientists

Collaboration between scientists and museum professionals was another practice encouraged by NISE Net, and again an area in which we observed change (Chapter 8). Before joining NISE Net, only one museum had nano-related partnerships with local scientists. After NISE Net involvement, three of the six study museums had partnered with nano researchers. Responses from both scientist partners and museum staff members highlighted how NanoDays events acted as a catalyst and provided opportunities to begin or deepen joint work. Even at the site where the partnership was brief, the relationship reflected a short-lived change in how the organization connected with an outside scientist and engaged the public in nano. For the other

two sites, the partnerships initiated by NanoDays events were anticipated to continue into the future and were evidence of long-lasting changes in the museums' programming efforts. Overall, it was clear that for these collaborations to take place, an alignment of museum and partner goals, from which both parties benefited, was critical. Moreover, the annual nature of the NanoDays events enabled the partners to stay in touch. Nonetheless, staff turnover and communication difficulties were two factors that sometimes hindered the lasting nature of the relationships.

D.9.2.2 Organizational change was facilitated when alignment of goals and the spread of information led to participation and reification of practices that affected how the museums functioned as a community.

As seen in the findings above, many of the products created by the NISE Net, such as the *Nano* exhibition and the NanoDays kits, aligned with the organizations' goals or typical work. At times, so too did some of NISE Net's non-nano practices, such as universal design or the practice of partnering. When there was alignment and an awareness of NISE Net products and practices among many staff, our data indicate that organizational change took place. The communities of practice framework helps explain how this change occurred because NISE Net, in essence, impacted the museums' mutual engagement and shared repertoires. When museum staff turned to nano or NISE Net products and practices as a way to carry out their joint enterprise, our study shows that being in the Network affected their community of practice on a larger scale (Wenger, 1998a). For instance, at several of our sites where multiple staff members were active with nano, either because they had attended NISE Net gatherings or because they had been trained on the activities and used them with the public, nano often became incorporated into the museums' offerings. The museums' mutual engagement expanded to include nano and a variety of practices encouraged by the NISE Net, even if only for a short time. For this work, the museums relied on the Network's kits, exhibit components, and other supplies. Thus, the NISE Net was able to introduce new activities and resources that became part of the museums' shared repertoires.

Indeed, our data indicate that NISE Net impacted the museums' mutual engagement and shared repertoires through the process of participation and reification, which according to communities of practice literature were two specific ways that change can occur (Wenger, 1998a). In particular, NISE Net affected how the museums took new practices and formalized them into the work of the larger group (i.e. process of reification). Reification occurred when staff indicated that they were going to maintain in their everyday practice NISE Net ideas. Data show that these ideas spread through museums due to the use of Network's products (i.e. boundary objects) or from the people who had directly participated in NISE Net professional development opportunities (i.e. brokers). Both boundary objects and brokers were key to incorporating NISE Net practices and nano information into the work of the museums, even if brokers functioned differently at the various sites whether they were solo individuals, pairs of professionals who worked together, or multiple people who had direct interaction with the Network over time. Nonetheless, instances of change through reification occurred when the *Nano* exhibition became integrated into the museums' official exhibit rotations or when staff wanted to replicate the supplemental materials and supplies that came with the NanoDays kit to develop their own programs. Reification also came about when staff who interacted directly with

the Network had been introduced to new ways of doing things, such as staff development, and then put what they absorbed into practice.

Moreover, NISE Net affected how staff at the museums worked together and shared ideas (i.e. process of participation). For example, due to NISE Net there were often multiple opportunities for staff to work with each other and the public by participating in nano-related activities. This happened when multiple staff from one museum were invited to take part in NISE Net gatherings, but also when several staff helped out at NanoDays events or attended a *Nano* exhibition training. These opportunities allowed for the exchange of new ideas and the process of participation, thus, integrating new ways of doing work into the museums communities.

Taken together, these various examples indicate how NISE Net impacted the shared practices of the museums. They also point to how the work of the Network, when it aligned with what the museums were trying to achieve, affected how the museums accomplished their own joint enterprise. For instance, by doing nano, museums were able to provide the latest STEM content to their audiences or connect with scientists and with their local communities. As seen above in the descriptions of the process of participation and reification, the museums were able to accomplish their own goals while integrating some of NISE Net's ideas. Overall, our study illustrates how being in an outside network such as NISE Net can lead to changes in how the museums typically performed their work and met their goals.

D.9.2.3 Organizational change was hindered when new practices did not align with the work of the museums or were not shared widely; these factors were sometimes beyond NISE Net's control.

Where there was a misalignment between the goals of NISE Net and the museums or when there were barriers to information flow within the organizations or between partners and NISE Net, data indicate that it was more difficult to accomplish change and affect the three key characteristics of communities of practice (i.e. joint enterprise, mutual engagement, and shared repertoires). For example, presenting nano content did not always align with school curriculum or there was little interest in implementing practices encouraged by the Network such as gathering evaluation feedback or engaging bilingual audiences. In these cases, it was unlikely that staff at the museums would discuss these new areas of work, integrate these ideas into their formalized practices or resources, or connect them to their common, underlying goals.

It is important to note that when NISE Net was unable to affect long-lasting change, this was often due to the museums' contextual factors which were beyond NISE Net's control. While NISE Net was able to specify the content and practices, as well as the design of its various products that it wanted to introduce to organizations, the Network could not address all of the internal barriers arising within museums. Even though NISE Net provided support and useful resources, issues related to staff transitions, changing organizational goals, or lack of permanent programming space meant that newly introduced nano offerings sometimes lasted only temporarily. Similarly, contextual factors, such as competing priorities, lack of time, and lack of nano scientists in the local communities, impeded the adaption of practices encouraged by the Network. The internal structure of the museums also could affect whether or not change occurred because it influenced the number of people who worked with nano and the possibility of

information from NISE Net spreading through formal and informal means. For example, our study saw less change when staff worked alone, either due to specific responsibilities or time constraints, than when multiple staff were able to engage in joint efforts. Likewise, change was hindered when staff were unable to share their NISE Net experiences in-depth, especially those related to gatherings, due to time restraints on meetings or other competing priorities. By gaining detailed insight into how the sites functioned, this study shows key internal limitations to change.

D.9.3 IMPLICATIONS FOR THE FIELD

D.9.3.1 Other networks can encourage change by adopting similar strategies for sharing their messages such as offering a range of flexible resources, professional development experiences, and reoccurring events; they can also look for additional ways to influence museums' practices.

The instances of change seen in this study suggest several takeaways for other networks hoping to impact their partners. Indeed, NISE Net was often able to lead to organizational change because it influenced the museums' set of mutual goals, practices, and resources. Overall, the generality of NISE Net's goals often allowed museums to meet their own aims by participating in NISE Net, and the range of different types of materials and opportunities encouraged by the Network promoted widespread, even if not always long-lasting, adoption of new exhibits, programs, and types of work. Future projects and networks may want to take into account similar strategies for influencing ISE organizations.

In particular, by creating products such as the *Nano* exhibition and the NanoDays kit materials that were flexible enough to align with museums' current goals and efforts, the Network was able to influence the types of public offerings at these organizations. Although the *Nano* exhibition was less likely to be affected by contextual factors than the NanoDays kit materials were, it was evident that offering easy-to-use and adaptable resources meant that the organizations offered new content to their visitors. Almost all the museums in our study certainly planned or hoped to continue offering nano-related exhibit experiences and some of their nano programming in the future. These products also created opportunities for information about nano to spread widely within the organization, such as through training sessions or through opportunities for multiple employees to facilitate nano-based programming. Thus, other networks may want to take into account similar approaches for influencing ISE organizations. Yet, our findings suggest that when making decisions about the types of changes they hope to encourage and the kinds of products they want to employ, other networks may want to be aware of how exhibits and programs have, perhaps inherently, different lifespans.

In regards to non-nano practices, the Network offered specific resources and professional development opportunities to help museums integrate work that was often new to them. Findings from this study again suggest that when goals aligned and when information flowed to many staff who could implement the practice in their everyday work, that organizational change could occur. In particular, because findings show that it was possible to strengthen museum partnerships with scientists through a network, much can be learned from the NISE Net's strategies in this area. For example, NISE Net offered opportunities, such as the reoccurring

NanoDays event, for scientist partners and museum professionals to meet, work together, and accomplish shared goals.

Besides providing a range of flexible resources that supported the goals of the museums, findings suggest that in order for products and practices from NISE Net to become institutionalized, it was important for multiple people to be able to share and implement these ideas. Not only did this create many opportunities for nano engagement, but it helped guard against barriers such as knowledge loss when staff transitions took place. Indeed, it was especially important for the staff members who bridged NISE Net and the museum communities to be in positions where they were involved in training and interacting with others, setting policies, or developing and implementing programs, exhibit, or content. Other networks may want to consider how they can support staff in these roles and aid them in the sharing their network experiences through formal and informal means.

This study also indicates that some practices encouraged by the Network, such as those related to nano and society, new engagement practices, or evaluation, did not become ingrained in the work of the museums. This was often due to contextual factors including a lack of time, departure of staff, and mismatched goals. In these instances, the practices did not become imbedded in the museums as a whole through reification or participation. These findings imply that when introducing new practices, it is critical to be aware of constraints of the community and to try and plan ahead for them. Despite the various efforts of NISE Net to support these areas of work, the general lack of sustained change further emphasizes how hard it can be to encourage these types of practices within an organization and suggests that there could be additional ways to accomplish this work.

D.9.3.2 Future studies can learn more about how organizational change occurs in museums, especially in regard to participation in other types of networks that may employ different products or forms of communication; additional research could also look at how to better embed certain practices into the long-term work of an organization.

A communities of practice framework allowed us to take an in-depth look at the six museums in this study and to gain insight into factors that affected change in organizations taking part in a large network. This approach provided a holistic view of each organization and a lens for looking at how the museums functioned on a day-to-day basis and whether or not they absorbed new ideas. Still, there is more to discover in terms of how museums grow and learn.

Because there had been little prior research examining organizational change in museums, this project purposefully had a broad view of what change might look like. Our research has shown that museums may experience change in terms of their educational offerings, practices, and partnerships when participating in networks devoted to informal science education. Additional studies could consider how museums are impacted when they come in contact with other networks, organizations, or even funding sources that have more divergent missions. By using a communities of practice framework, future research could see how and why these other groups might affect museums in terms of their mutual goals, practices, and resources. Depending on the aims of other external networks, further research might uncover similar or new types of changes.

The communities of practice approach also allowed us to learn about the types of products and circumstances that permitted information to flow through an organization and to take root in the museums' typical practices; other work could continue in this vein and further explore how this is best accomplished. Our study found that having products which aligned with the museums' work and having opportunities for many staff to learn about and implement nano ultimately supported the long-term inclusion of new types of work. Future research could discover other techniques or different types of products, professional development offerings, or communication that could also be successful in integrating ideas into an organization.

Because this study saw several instances when nano programming or incorporating certain non-nano practices only lasted for a short-time, additional studies could aim to better understand what strategies sustain and embed these efforts within an organization. According to our research, many of these factors depended on museums' context. Research could help understand what, if anything, outside communities could do to increase their chance of surmounting these barriers or what museums could do to support long-term change in these areas. Related questions raised by this study include how organizations ensure that knowledge or practices stay within a community when people leave, change roles, or are too busy to share information with others. What, if anything, can be done to better support the continuation of programming within museums even when programs often change on a regular basis? If there is a misalignment in goals or practices between the network and museums, how can these areas be better aligned to increase impact? And what additional support do museums need in order to ingrain practices related to evaluation, diverse audiences, or new techniques for audience engagement? Finally, future studies could look at organizations involved in the NISE Net several years down the line to see if any acquired ideas and practices have become fully embedded. Researchers would then have a better sense of whether or not long-term changes such as the ones that we identified had lasting staying power. This research would add to the understanding gained by our study illustrating NISE Net's influence on participating organizations.

These additional areas of study would add to the knowledge base of how organizational change occurs in museums. Yet our research has taken a significant step in illustrating how participating in a network can, indeed, promote change among informal educational organizations. Whether through the addition of new exhibits or programs focused on nano, the adaption of practices encouraged by the Network, or the creation of productive partnerships, the museums in our study experienced change in their work. While there were only six museums in this study, they embody characteristics of the broader ISE field in terms of their goals, typical activities, and staffing structures. Thus, our findings underscore how networks, and in this case the NISE Net, played a noteworthy role in adding new ideas and resources to the often ongoing practices of informal science organizations.

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APPENDIX A: INTERVIEW INSTRUMENT EXAMPLE

NISE Net Research on Organizational Change

Site Visit 2 Interview: Repeat Participants

INTRODUCTION

Our first visit on [date] was very helpful for getting a sense of your institution. The purpose of this visit is to see what has changed since we last visited, including general changes as well as any changes in NISE Net activities and NISE Net's impact on your science center. Of course, it's possible that the impact of your museum's involvement in NISE Net has been minimal, and I'm interested in that, too.

But first I want to cover informed consent for the interview. Your participation is completely voluntary. If you'd rather not participate, we can stop now and I won't tell any of your colleagues or supervisors about it. You can decide not to answer any question, and all of your answers will be confidential.

I am hoping that you are okay with me audio recording the interview. The purpose of audio recording is so that I don't have to completely rely on my notes later on when we are doing data analysis. If you would prefer not to be audio recorded, you can still participate in the interview. Here is a form for you to look over. Let me know if you have any questions.

[AFTER CONSENT FORM IS SIGNED]

I'm going to begin by asking some questions about you and your museum and then turn to NISE Net. I'll ask you some general questions about your museum and NISE Net, and then I'll ask about your personal involvement in NISE Net.

Keep in mind that although I'm interested in your own experiences, I'm especially interested in how NISE Net may have affected your organization. For instance, you or some of your colleagues may have learned something at a NISE Net meeting that you or they brought back and shared with other colleagues. And it may be an indirect effect—that is, perhaps you learned something in NISE Net that you then applied to some topic completely unrelated to nanoscience. I'm interested in those kinds of things, too.

One more thing to keep in mind: This is not an evaluation—the research team is not judging how well the Network has been doing. Instead, it's a research study, and we're interested in all the different ways NISE Net may or may not have affected its partner museums and to talk about why some things worked and some did not.

OK? Do you have any questions before we get started?

PART 1: CONTEXT

First, I'd like to check in with what you've been up to in your position.

Last time we talked in [date], you were the [job title]. Has your title or any of your responsibilities changed since then?

- [If so] What has changed and why?

Have there been other structural changes in your science center? By structural changes I mean changes to how the museum is organized, to the various departments or positions, or staffing changes?

- [If so] What has changed and why?

[Updates on other contextual information that may be relevant to your site]

PART 2: [CHANGE IN] THE MUSEUM'S EDUCATIONAL GOALS

Let's start with your museum.

How, if at all, has your science center's educational mission or goals changed since we last visited in [date]? [May need to remind them what was going on then.]

- If they mention NEW goals:
    - Can you give me some examples of how the museum tries to accomplish that mission or goal?

- If they mention the SAME goals:
    - What new programs or activities are you offering to help you accomplish those goals?

- If they don't mention a goal from last time:
    - Last time you also mentioned [goal]. Is this still an important focus for your science center? Why/why not?

- Probe about professional goals/changes, <u>if appropriate</u>
    - What are you trying to accomplish in your work?
        - Do you have any goals in addition to or different from the museum's goals?
            - [If so] Where do they come from?
            - Do they ever come in conflict with the museum's goals?

PART 3: [CHANGE IN] NISE NET'S EDUCATIONAL GOALS

Now I'd like to ask a few questions about NISE Net.

Do you see any connections between NISE Net's efforts and the aspects of the museum's mission that you were just mentioning?

- [If yes] What are those connections?

- [If no] Are there other aspects of your mission that you did not mention here that NISE Net's efforts connect to?

What is your current understanding of NISE Net. [Probe if people don't understand question: What is NISE Net trying to accomplish?]

- Is that a change in your understanding NISE Net?

    o [If so] What led you to change your understanding?

Do you think NISE Net has changed in any way since we last spoke?

- [If so] What do you think has changed about NISE Net?

- Why do you say that? Where are you seeing this change?

- Has this change in NISE Net impacted your museum in any way?

PART 4: [CHANGE IN] NANO INVOLVEMENT

What has your science center been up to recently with respect to nano?

- Any new programs/events/activities since my last visit? Any new exhibits?
    - Probe for details about the new programs/events/activities/exhibits:
        - Who is involved with these?
        - How often do they occur?
        - What are you hoping to accomplish through them?
- Are these new nano experiences related to your involvement in NISE Net?

Have you discontinued any nano programs since we last talked?

- [If so] What happened there?

- [If not] So it sounds like [list some nano programs from before] are still going on?
    - Why have these programs continued to be offered?
    - Who is involved with these right now?
    - Are they occurring at the same frequency as last time we spoke?
    - Do you foresee these – or other programs about nanoscience – continuing in the future, when NISE Net is over?

PART 5: NISE NET IMPACT

- Overall, what impact do you think NISE Net has had on how you do your work? On you personally?

- What impact do you think NISE Net has had on the museum?
  - o Has this changed over time?

- Do you think other staff members in the museum are aware of your museum's involvement in NISE Net?
  - o [If yes] How have they learned about NISE Net?
  - o [If not] Why do you think they are not aware of the museum's NISE Net work?
    - Is there anything that hinders them from knowing about the institution's NISE Net involvement?

- How could NISE Net have a greater impact on your museum?
  - o Are you aware of any obstacles that prevent NISE Net from having a greater impact on your museum?

PART 6: NISE NET ACTIVITIES

Now I'd like to ask you about your involvement in different NISE Net activities.

PART 6A: NANODAYS

Let's talk about NanoDays first.

Do you know what your science center's most recent NanoDays was like? [If so,] Can you tell me a little bit about it?

- What was your role for NanoDays this year?
- Was this NanoDays any different from your previous NanoDays?
- What was your science center trying to accomplish during NanoDays?

Do you see your institution continuing to do NanoDays in future years?

- What about after NISE Net is over and you don't get a new kit each year?

Do you use the NanoDays kit outside of the NanoDays event? How so? [Probe: Carts on the floor, demonstrations, in programs (afterschool, summer, schools, theater etc.)]

- Do you think you would use the NanoDays kit materials you've already received in the future? Even after the NISE Net grant period is over?
- How would you use them?

How does information about the kit or NanoDays work spread among staff at your museum?

- Are there particular people who help make this happen?

- Formally? Informally?

[IF APPROPRIATE]

PART 6B: MINI-GRANT

Let's talk about your science center's mini-grant project(s).

CHECK-IN ABOUT MINI-GRANT FROM LAST SITE VISIT [If applicable]

How has everything been going with [mini-grant project]?

- Who has been working on this project?
- What has been your involvement with this mini-grant work?
  - If interviewee was involved:
    - Have you finished what you set out to do?
    - Did anything change with the direction you were taking this project since we last talked?
    - Were you able to do everything you were hoping with this mini-grant project?
- Did this project lead to any other changes in your science center?
- Did you learn anything from this mini-grant project? [If so] What did you learn?

NEW MINI-GRANT PROJECT [If applicable]

Are you familiar with the new mini-grant the museum received from NISE Net? [Have details from QuickBase on hand]

- [If yes] Could you tell me a little bit about this project?

  - What were you trying to accomplish?

  - How does the mini-grant fit into your museum's mission?

    - How does the mini-grant relate to things you were already doing?

    - What makes what you're doing with the mini-grant different from other activities or programs at your museum?

- Did you have a role in applying for the mini-grant?

  - [If yes] Describe your role:

    - How did you get involved in the mini-grant?

    - What were your personal goals for the mini-grant?

    - Who else was involved in applying for the mini-grant? What did they do?

- Are you involved in the project that the mini-grant made possible?

  - [If so] How are you involved?

  - Who do you work with on this project?

- How do you work together? What do they do?

- What impact has the project funded by the mini-grant had on your work?

  o What, if anything, have you learned from the project?

- What impact has the project had on the museum?

  o Has the mini-grant or the project it funded led to any other changes in the museum?

  o Are there any long-term outcomes from the mini-grant or the project it funded? Impacts beyond the grant period?

    - [If so] What are those?

- How does information about mini-grant spread among staff at your museum?
  o Are there particular people who help make this happen?

    - Formally? Informally?

<mark>[IF APPROPRIATE: Review and customize before the site visit: Only one section below will apply to each site.]</mark>

PART 6C: MINI-EXHIBITION

Now I would like to check in about the mini-exhibit your science center received from NISE Net.

6C.1: HAD MINI-EXHIBITION ON FLOOR LAST TIME

How has everything been going with the mini-exhibit? Has anything changed since my last visit?

- Is having the mini-exhibit leading to any other changes in your science center?
  - Any nano programming occurring around the exhibit?
  - Any new trainings or staff PD?

- Were you able to do everything you hoped with the mini-exhibit?

- Now that you've had the mini-exhibit for a couple of years, what impact would you say the exhibit has had on your science center?
  - On visitors? On staff? On volunteers?
  - Do you think this will be a lasting impact?

6C.2: KNEW WOULD RECEIVE MINI-EXHIBITION LAST TIME, STILL DON'T HAVE IT

I know you are still awaiting the mini-exhibit. Do you have any plans for the exhibit once it gets here?

- Where is it going to go?
- Once it gets here, how do you expect staff to become aware of it?
  - Trainings?
- Have you made any plans yet for programming or events related to the exhibit?
  - [If yes] Do you know what the programming might look like?
  - Are you planning an opening event?
- What impact do you expect the mini-exhibit to have on your museum?
  - On staff? On visitors?
  - Do you think this will be a lasting impact?

6C.3: KNEW THEY WOULD GET THE MINI-EXHIBITION LAST TIME, JUST RECEIVED IT

I know you just received the mini-exhibit, but I want to ask some questions about what's been going on related to the exhibit.

- Are other members of the staff aware of the mini-exhibit? How did they become aware of it?
  - Any trainings?
- Have you had any programming or events related to the exhibit?
  - Did you have an opening event once you received the exhibit?
  - Are you planning to add any programming around the exhibit?
  - [If yes] What will that look like?
- I know it has only been here a short time, but how do you expect the mini-exhibit to affect your museum?
  - On staff? On visitors?
  - Do you think this will be a lasting impact?
- Have you noticed any other changes in the museum since having the exhibit?

6C.4: DIDN'T KNOW THEY WERE GETTING IT LAST TIME, BUT HAVE RECEIVED OR PLAN TO RECIVE MINI-EXHIBITION

Little knowledge of NISE Net/the mini-exhibition

- What do you know about the mini-exhibit?

  - How did you hear about it?

  - Do you think the mini-exhibit may relate to the work you do here?

For people with A LOT of knowledge of NISE Net/the mini-exhibit

- Describe your application for the mini-exhibition:

  - What are you hoping to accomplish with the mini-exhibit?

  - How does the mini-exhibit fit into your museum's mission?

    - How does the mini-exhibit relate to things you already were doing?

    - What makes what you're doing with the mini-exhibit different from other activities or programs at your museum?

- Did you have a role in applying for the mini-exhibition?

  - [If yes] Describe your role.

    - How did you get involved in the mini-exhibit?

    - What are your personal goals for the mini-exhibit?

    - Did you work with anyone else on the application for the mini-exhibit?

      - [If so] Who? How did you work together?

- What impact do you expect the mini-exhibit will have on your museum?

  - What do you hope to learn from having the mini-exhibit?

PART 6D: OTHER NISE NET PRODUCTS AND RESOURCES

I have a couple of questions about the website and other NISE Net products.

Have you been on any of the NISE Net websites [nisenet.org or whatisnano.org] recently?

- [If so] When?

- Why? What did you do there?

- Did you learn anything?

Have you used any other NISE Net products or resources recently (outside of the NanoDays kit)? [Probe: Such as material you may have brought back from a meeting, training guides, etc.]

- How have you used them?
- Have you modified them in any way?

    o [If yes] How? Why?

PART 6E: ATTENDANCE AT NISE NET MEETINGS

Now I'd like to ask some questions about NISE Net meetings.

- Have you attended any NISE Net meetings or [online] Brown Bag Webinars since my last visit?

For people who HAVE NOT attended any meetings or Brown Bags (or who haven't been to one recently):

- What, if anything, have you heard about the NISE Net meetings that some of your fellow staff members have attended recently?
- Have you learned anything about those meetings that led you to do something differently?
  - o [If so] What?
- Have you seen any other changes at the museum as a result of staff attending recent NISE Net meetings?
- [For people who have attended NISE Net meetings in the past, but haven't been recently] Do you know how decisions are made about who gets to go to meetings?

For people who HAVE attended meetings or Brown Bags Webinars:

I see that you've been to these meetings since our last visit: [FROM DATA MINING PREP]

- Have you been to any other meetings not on my list? Any Brown Bag Webinars?
- For the meeting(s) attended recently: [repeat as needed for each meeting]
  - o What sticks with you from this meeting? Why?
  - o What did you learn from the meeting?
  - o As a result, was there something you wanted to do differently when you got back to the museum? To use what you had learned?
    - ▪ Describe what you wanted to do.
      - Were you able to do that?
      - Is there anything that has helped you in your efforts to use what you learned?
  - o Is there anything that hinders you from using or sharing what you learn at these meetings? Did you share what you learned with other people?
    - ▪ [If so] How did you share it with them?

- Do you think they learned anything? What?
        - Do you think it changed how they do their work here?
    - Did what you learn affect anything else at the museum?
- How was it decided that you should attend these meeting?
    - Why were you selected to attend?
    - Were there specific goals for you to do or share anything when you got back from the meeting?

PART 6F: NISE NET'S INFLEUNCE ON PARTNERSHIPS

We want to check in about partnerships that NISE Net has influenced in some way.

[By *partner* I mean an ongoing relationship in which you work with someone outside your museum to design or deliver programs, create new exhibits or activities, or collaborate in other ways. It could be with one or more people from other museums, scientists from universities or industry, or other people from outside your museum.]

- How important is it for your museum to create partnerships with researchers?
- Are you aware of any new partnerships that the museum has formed related to nanoscience or connected to NISE Net?

For new partnerships:

- Tell me about the partnership.
  - What kinds of things have you worked on together?
  - What does the partner do and what do you do?
  - What is NISE Net's role in the partnership?
  - How did you start working together?
- What do you think they hope to accomplish by working with you?
  - Do you think their goals are the same as yours?
  - Are there ever any difficulties working together?
    - [If so] What do you think is the source of those difficulties?
- What have you learned from working with the partner?
  - Has the partnership affected what you do at the museum?
  - Has it had any more general influences, beyond specific projects?
- What do you think the partner has learned from working with you?
- Do you think the partnership will be sustained beyond current projects?
- Have you learned anything from NISE Net about working with researchers?
  - Have you learned anything about the kinds of activities you could do with them?
  - Have you learned anything about what scientists value in a partnership with a museum?

Check-in about partnership from Site Visit 1:

- Have you done anything with [institution name] since our first site visit [date]?
  - Please describe
- Are you still connecting with [institution name] now?
  - [If so] Has anything changed in this partnership?
    - Do you still participate in [these activities] with them?

    - Have you started doing anything new with this partner?

    - Have your goals for partnering with them changed at all?

    - Do you think their goals for partnering with you have changed?

    - Have you learned anything new because of this partnership?

    - Do you think this partnership will be sustained beyond current activities?

    - What is NISE Net's role in this partnership?

  - [If not] What happened? What changed that slowed down or hindered the partnership? [PROBE: Did your goals for the partnership change? Did the partner's goals change?]

  - How, if at all, has your involvement with NISE Net affected this partnership(s)?

No current partnerships:

Have you learned anything from NISE Net about creating or sustaining partnerships?

- [If so] What have you learned? Where or how did you learn this?
  - Have you learned anything about the kinds of activities you could do with researchers?
  - Have you learned about potential partners in your community?
  - Have you learned anything about what scientists value in a partnership with a museum?
- Have you applied what you learned at all?
  - Could you give me some examples? [More examples may not be needed, if just went through partnership section]

- Have you shared what you learned with others in your museum?
  - With whom?

  - What info did you share?

  - How did you share it?

PART 7: NISE NET'S INFLUENCE BEYOND NANOSCIENCE

Although NISE Net is specifically focused on nanoscale science and technology, I'm wondering if being involved in NISE Net had any effects on you or your museum beyond nano.

7a. Evaluation

Let's talk about any influence NISE Net has had on evaluation. By evaluation, I mean using data to help make decisions. Data could be informal, like asking staff members to reflect on their experiences, or more formal, like using surveys or interviewing visitors.

How important is it for your museum to do evaluation?

What, if anything, does your museum do with respect to evaluation?

Have you learned anything from NISE Net about evaluation or using data to help make decisions?

- [If so] What have you learned about doing evaluation?
- Where or how did you learn this? How is this connected to NISE Net?
- Have you applied what you learned about doing evaluation at all?
    - Could you give me some examples? (That is, have you been doing any evaluation as a result of your participation in NISE Net?)

- Have you shared what you learned about doing evaluation with others in your museum?
    - With whom?
    - What did you share?
    - How did you share it?

7b. Societal and ethical implications of science/technology

Now I'd like to talk about the societal and ethical implications of science and technology. By this I mean engaging visitors in discussions about costs and benefits, risks, and uses of science and technology, and how they are connected to society and our values.

How important is it for your museum to address societal and ethical implications of science/technology?

What, if anything, does your museum do with respect to societal and ethical implications of science/technology?

Have you learned anything from NISE Net about societal and ethical implications of science/technology?

- [If so] What have you learned? Where or how did you learn this?
    o Have you learned anything about methods to engage visitors in conversations about SEI?
- Have you applied what you learned at all?
    o Could you give me some examples?

- Have you shared what you learned with others in your museum?
    o With whom?

    o What info did you share?

    o How did you share it?

7c. Reaching new audiences

Now I'd like to ask a few questions about reaching new audiences. Here I am particularly referring to ways that your museum may attempt to include people with disabilities, audiences whose first language is not English, adults, and young children.

How important is it to your museum to engage these four audiences at your science center?

- Adults, young children, people with disabilities, bilingual audiences?

What, if anything, does your museum do with respect to engaging these four audiences?

How appropriate do you think nano is for your science center?

- Audiences with young children?

Have you learned anything from NISE Net about reaching any of these audiences?

- [If so] What have you learned? Where or how did you learn this?
    o Have you learned anything about universal design? Anything about creating bilingual labels?
- Have you applied what you learned at all?
    o Have you applied universal design? Created bilingual labels?

   o Could you give me some examples?

- Have you shared what you learned with others in your museum?
  - With whom?

  - What info did you share?

  - How did you share it?

7d. Being part of a national community

I have a few questions about being part of a national community. Here I am thinking of how you may have shared practices with others about your nano education efforts through conferences, informal meetings, and discussions.

How important is it for your museum to be part of bigger communities of science centers, such as NISE Net?

- If it is important, how is it supported?
- Why does your museum value this?

Do you feel like your museum is playing a role in the larger community of NISE Net?

PART 8: SUSTAINABILITY QUESTION

I have one last question for you about your museum's involvement in NISE Net.

After NISE Net is gone, what aspects of it do you think will continue in your museum?

   o   What do you think will change?

Part 9: FOLLOW-UP FROM SITE VISIT 1

[Use this space to write down questions you want to ask from the first interview with each participant. Where are the gaps in this case? What is important to specifically follow up about? Is this person featured in any memos that you may want to look into further/test?]

APPENDIX B: NETWORK CORE PARTNERS DATA CHECK MATRIX

- **Topic:** Which topics have been made available to Partner Museums?
- **Practice:** Which practice(s) about this topic have been made available to Partner Museums?
- **Idea/Knowledge**: Which ideas/knowledge around this topic have been created and made available to Partner Museums?
- **Value**: Which values are being conveyed to Partner Museums and why is this topic important to NISE Net?

Table 3. Topics, Ideas, Values, and Practices the Network has Made Available to Partner Museums

Topic	Practice	Idea/Knowledge	Value
Nano Content	Facilitating informal science learning experiences about nano	Knowledge and understanding of nano content	Informing the public about nano is a valuable endeavor
		Knowledge and understanding of the nano content that could/should be conveyed to the public (Concept map is part of this idea)	Science museums have a role to play in educating the public about current research related to science and technology
Evaluation	Embedding evaluative thinking/ on-going data collection/reflection/ into their practice	Knowledge of how to collect data, reflect upon data, and make decisions/take actions based on data	Museum professionals perceive that gathering and reflecting upon data is an important part of their practice
			Museum professionals perceive that gathering and reflecting upon data is critical for improving products and practices so that they more effectively engage audiences

Topic	Practice	Idea/Knowledge	Value
Scientist-museum Partnerships	Collaborating with a local researcher/university on informal science education activities	Knowledge of the kinds of activities where a researcher/university could contribute Knowledge of who potential partners are within your community Knowledge of what researchers/universities value when it comes to informal science education	Researchers can make valuable contributions to museum's informal science education efforts
Societal and Ethical Implications of Nano	Engaging staff members, volunteers, and visitors in conversations about nano costs, utilities, risks, benefits and how they are closely connected with society and our values	Methods you can use to engage visitors in conversations about SEI and nano Knowledge of potential societal and ethical implications of nano	It is appropriate and/or necessary for science museums to address or refer to SEI and nano in its programming or exhibits Valuing public engagement of science and public understanding of science
Reaching Underserved Audiences	Applying/using universal design to create/implement museum programs or exhibits to include people with disabilities Creating/using bilingual labels in exhibits or programs to include people who speak Spanish	Awareness of the diversity of abilities and disabilities that are within museum audiences Awareness of the ethnic/linguistic diversity present within museum communities Knowledge of practices (including universal design and Spanish translations) museums can employ to engage a diverse range of learners in informal science education Methods for engaging in conversations with local community partners to learn more about their needs, preferences, concerns, etc.	It is important to develop and implement informal science education experiences in a way that is inclusive of a broad range of learners Learning about nano is appropriate/important for all of your audiences

Topic	Practice	Idea/Knowledge	Value
Engaging Young Children in Learning About Nano	Engaging young children in nano programs/exhibits	Knowledge of activities you can use to engage young children in learning about nano	Learning about nano is appropriate/ important for all of your audiences
Engaging Adult Audience in Science Museum Learning	Creating/implementing programs that serve adults	Knowledge of programs/activities science museums can employ to attract and engage adult learners	Learning about nano is appropriate/important for all of your audiences Science museums can be a place for adult learning
Being Part of a National Community	Sharing practices with others about nano education efforts (through conference presentations, informal conversations, regional meeting discussions, etc.)	Knowledge of ways museum professionals can contribute their ideas and share what they have done with other members of the network	Learning from and contributing to NISE Net will improve their work Feeling like they play a role within the larger Network and that the work they have done is meaningful
Science Museum Education as a Profession	Museum educators seek out opportunities to further their work through ongoing professional development Museum educators learn by working together Museum educators use improv and inquiry-based learning to engage audiences Museum educators use expertise to modify or adapt NISE Net products to fit needs of their museum and their audiences Museum educators implement professional development trainings for their staff members/volunteers/ university partners	Awareness of the PD opportunities that exist in the field Knowledge of effective practices within the field that one can use and learn from Knowledge of ways to increase the capacity of staff members/volunteers/partners through professional learning experiences Awareness that museum professionals are part of the ISE field and can learn from one another	Providing professional development will raise the capacity of the ISE field as a whole Learning from and contributing to the science museum field will improve your work and the field. Feeling like they play a role within the science museum field and that the work they have done is meaningful