

NISE Net Years 6-10 Evaluation Summary

Report

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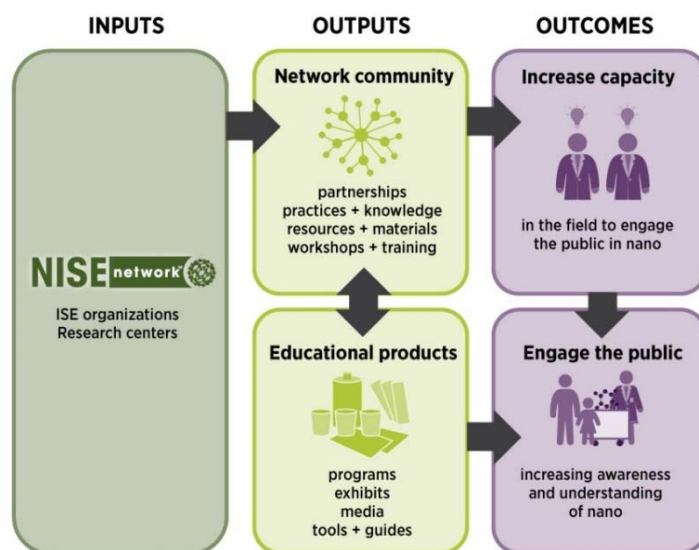
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Executive Summary

The purpose of this report is to summarize the findings from the Years 6-10 (2010-2015) Nanoscale Informal Science Education Network (NISE Net) summative evaluation studies and to discuss factors that contributed to the achievement of NISE Net’s goals. The report centers on summative evaluation findings, while also including major project output data and corroborating findings from the Years 6-10 NISE Net research studies. By synthesizing findings across studies, this summary evaluation report provides a high-level description of the cross-cutting and integrated knowledge generation efforts the Network was involved in during Years 6-10.

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 Network, 2014, para. 1). Originally funded by the National Science Foundation (NSF) in 2005, the NISE Network received two consecutive NSF grants and a supplement that extended over 11.5 years and amounted to over \$41.7 million. NISE Net, one of the largest education initiatives ever undertaken by the agency, was unusual among informal science education (ISE) projects due to its content focus, size, and timeline.

To guide the work for Years 6-10 of the project (2010-2015), NISE Net Leadership created a logic model for the Network. The logic model explained the strategies that NISE Net used to achieve its goals. These strategies were thought of as two main strands of work. Strand 1 focused on using the Network to build a community and increase individual professionals’ capacities to engage the public in learning about nano. Strand 2 emphasized leveraging this community or these professionals to deploy the products NISE Net produced to reach the public. These strands of work were deeply interconnected as can be seen in the image below.



This logic model was used to set specific goals for the Network's public and professional audiences. Decisions about what to study as part of the Network evaluation were also based upon the impacts and outcomes described in the NISE Net logic model.

Overall, the evaluation studies showed that NISE Net met its goals for professional and public audiences. Ultimately, the Network engaged over 2,700 professionals, reaching over 30.4 million members of the public through its educational products and outreach efforts over a 10-year span (Svarovsky et al., 2015). As detailed in this report, NISE Net created a sense of community among partnering professionals, and through the Network, these professionals increased their understandings of nano and partnerships around this topic. The professionals used NISE Net products to engage their audiences in nano, leading visitors to have increased understandings of this content.

The bulk of this report centers on a discussion of how several aspects of NISE Net's work were crucial for accomplishing the above outcomes. In particular, the Network's organizational structure was important for creating a network community. NISE Net had a core group of institutions driving the work of the Network forward and clear systems in place, such as the Regional Hub structure and a variety of in-person and virtual meetings, that distributed information to its partners. These structures contributed to the growth of the Network which came to include 203 colleges and universities, 268 science centers and museums, and 127 additional organizations such as libraries, K-12 schools, and government and industry institutions.

Guiding but flexible frameworks along with training and support related to these resources helped provide a foundation for and contributed to the implementation of the Network's deliverables. Key documents that outlined four central content ideas were used to direct the kinds of content included in educational products and professional development. Additionally, the Network provided professional development opportunities to support the teaching of this content to various kinds of visitors. The Network also allowed partners to modify and adapt products or take part in specific opportunities, such as NanoDays or mini-grants, to enhance their capacity to engage the public in nano, if they wished to do so.

Besides these factors, all of which helped build a community with greater capacity to engage the public in learning about nano, the Network made specific choices that helped partners deploy NISE Net products. The Network chose formats, based on data from partners, that they saw were likely to be successful in and highly utilized by many institutions, such as hands-on activities or exhibits. Often these choices were based on small experiments with new formats or topics, before pursuing broad implementation. Throughout all of this work, the Network was attentive to the costs of producing, sharing, presenting, and maintaining products so that they could optimize the use and reach of the products through their partner organizations. These factors were important for accomplishing the work and outcomes articulated in NISE Net's Logic Model.

External reasons also likely supported the outcomes of the Network. For example, in creating a community, NISE Net was able to build on the fact that the ISE field already had professional organizations and mechanisms for sharing information through which they could recruit their partners and distribute resources. Additionally, NISE Net addressed a need within the ISE field for increased and freely accessible professional development opportunities and resources. In regard to outside conditions that may have played a role in the success of the Network's public impacts, it is important to note that the anticipated public reaction and possible backlash to nanotechnology did not occur, allowing museums to feel comfortable presenting nano content. Additionally, a desire for increased inclusion of current science topics in science and children's museums meant that partners actively welcomed the Network's nano content.

Overall, NISE Net achieved its goals; and the authors of this report hope that funders, leaders, and participants of the NISE Net, as well as those who may want to create similar types of networks, will benefit from this summary report. By hearing about the various decisions and aspects that played into how the Network created a community, increased professional capacity, and chose to design and deploy public deliverables, readers will gain an understanding of what led to the success of NISE Net. Together, these factors have allowed NISE Net to create a continuing informal science education network with goals beyond nano education.

Introduction

The purpose of this report is to summarize the findings from the Years 6-10 (2010-2015) Nanoscale Informal Science Education Network (NISE Net) summative evaluation studies¹ and to discuss factors that contributed to the achievement of NISE Net's goals. The report pulls together findings from completed studies to provide evidence of the Network's progress toward the achievement of its intended goals. No new data were collected specifically for this report, and no new analyses were conducted. The report centers on summative evaluation findings, while also including major project output data and corroborating findings from the Years 6-10 NISE Net research studies. By synthesizing findings across studies, this summary evaluation report provides a high-level description of the cross-cutting and integrated knowledge generation efforts the Network was involved in during Years 6-10.

Structure of this Report

This summary report follows the structure of a typical evaluation report with introduction, methods, findings, discussion, and conclusion sections. The introduction section provides the background of NISE Net. The methods section includes descriptions of the summative evaluation studies and research reports completed for NISE Net in Years 6-10 (2010-2015), as well as a table showing which studies provide information about the achievement of each NISE Net impact. The findings section provides a brief summary of evidence from the evaluation reports to help illustrate whether each impact was achieved. Findings from NISE Net research studies are also included to be illustrative and add additional support about the achievement of NISE Net impacts. The discussion section interprets the evaluation and research findings with regards to the Network impacts, describes ways the evidence suggest lasting effects of the Network on partners and the informal science education (ISE) field, and provides recommendations for future work. Finally, the conclusion section offers information about lessons learned from NISE Net and details about the continuation of the Network.

Background of the NISE Network

The NISE Network 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 Network, 2014, para. 1). Originally funded by the National Science Foundation (NSF) in 2005, the NISE Network received two consecutive NSF grants and a supplement that extended over 11.5 years and amounted to over \$41.7 million. NISE Net was one of the largest education initiatives ever undertaken by the agency. In 2016, NISE Net transitioned to an ongoing identity as the National Informal STEM

¹ The NISE Net Museums and Community Partnerships project summative evaluation took place in Years 11-12 (2015-2017) and was not completed in time to be included in this summary evaluation report.

Education Network, leveraging the investment of the National Science Foundation for new projects and collaborations beyond the nano project.

Many factors made NISE Net unusual among ISE initiatives:

- **Content:** Nanoscale science, engineering, and technology (abbreviated as “nano”) had not been widely presented in ISE institutions prior to the NISE Network, and ISE professionals were generally unfamiliar with this topic or how to present it to the public. Therefore, the NISE Network had to learn how to best engage the public in nano content through this project, think about how to present current science research, and raise the capacity of partner institutions to do this work.
- **Size:** From the beginning of the Network, products were created and implemented at multiple institutions. By the final years of the NSF funding, over a dozen institutions were creating products designed for national distribution through the Network, exhibits and activities were being used at hundreds of ISE organizations, and professional development was being conducted for thousands of ISE and research professionals. This project was unlike the scope of most ISE projects which tend to have fewer partners and sites that may run in dozens, but not hundreds, of organizations.
- **Timeline:** Not only was the NISE Network large, but the period of funding lasted longer than many NSF grant-funded ISE projects. Typical NSF projects for the ISE field only have funding for three to five years. Because of the extended NISE Net timeframe, the Network was able to change and be responsive to the needs of the partners over time. The roles of partners shifted, the roles of the workgroups changed, and, at some points, the goals for the project and its deliverables evolved.

Because the content, size, and timeline of NISE Net were unique, these factors have been key to the approaches and interpretations of the evaluation studies. As such, these elements will be referenced throughout the Findings and Discussion sections of this report.

NISE Net in Years 1-5

While this report concentrates on Years 6-10 (2010-2015), it is necessary to provide some context about the challenges the Network faced, how it operated, and what it accomplished in its first five years (2005-2010) to understand what the Network was able to achieve in its second five years. These contextual understandings are drawn from two evaluation reports, *Overview of NISE Network Evaluation* (St. John et al., 2009) and the *Review of NISE Net Findings: Years 1-5* (Reich, Goss, Kollmann, Morgan, & Nelson, 2011), and the formal report by Network Leadership to NSF on the work of the first five years of NISE Net, *Nanoscale Informal Science Education Network Final Report* (NISE Network, 2009).

In 2009, St John and colleagues identified four major challenges that NISE Net would need to work through in order to be successful. Those challenges were the following:

- Determine “the content and pedagogy of Nanoscience education” including “what is important to teach about nanoscience, and how to teach it.”
- “Design and develop high quality informal learning resources for others to use.”
- Develop “institutional capacity and readiness to implement nanoscience education” within both museums and research centers.
- Figure out how to develop and operate a “national supportive network”(pp. 3-4).

These challenges were presented to the Leadership and treated as significant. They were a central focus of NISE Net’s work in the first five years. In this time, products and practices were devised and network structures were put in place to complete the work. Some of the products, practices, and structures were highly experimental and did not continue after the initial five years of the Network, while others were refined and improved over time such that they continued to be used in Years 6-10.

At the end of the first five years, evaluators also looked across all of the public impacts reports that had been generated to understand the actual, possible, and potential public impacts of NISE Net and their implications for the work of Years 6-10 (Reich et al., 2011). This review reported that the Network was reaching hundreds of thousands of people across the US through their nano programming, and that this programming was enhancing museum visitors’ awareness, knowledge, and interest of nanotechnology. Additionally, the report found that participating ISE and university-affiliated professionals felt that NISE Net increased their capacity to engage the public in learning about nano. However, evaluators also identified possible areas for growth in NISE Net programming in Years 6-10, including:

- Expanding its offerings and increasing its impacts related to societal and ethical implications content;
- Enhancing the relevance of its educational offerings; and
- Increasing its efforts to reach under-represented audiences such as Spanish-speaking audiences and people with disabilities (Reich et al., 2011).

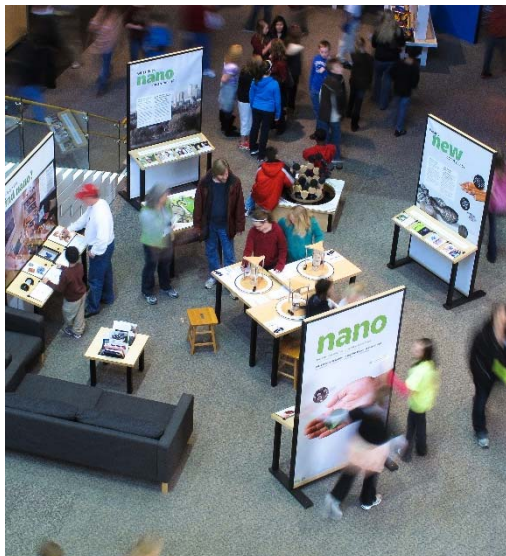
According to Network Leadership:

At the end of five years of work, it was clear that the network infrastructure had been built and that the task ahead was using the Network to engage the public. That is not to say that work on relationships and professional development was done, but only to say after experimenting with various approaches, the leadership team felt that it had identified and put in place the key elements to make the Network operate successfully. (NISE Network, 2009, p. 1)

Overall, looking back with the benefit of five years of subsequent work, this assessment is fairly accurate. The Network structures were relatively settled as of Year 5 (2010). In Years 6-10, the Network shifted its focus to product development within defined parameters and implemented these products with publics through their numerous and diverse partner institutions. To aid in the implementation of some of the newer and perhaps more challenging products and practices, NISE Net provided professional development opportunities.

NISE Net Outputs as of Year 10

Between 2005 and 2015, the Network expanded beyond the initially proposed 100 partner organizations to include 598 active, US partner organizations. These organizations were composed primarily of museums, science centers, colleges, and universities, but also included K-12 schools, libraries, and industry and government groups. Within these partner organizations, approximately 2,709 professionals, who included educators, administrators, scientists, and researchers, became involved in NISE Net. Over the ten years, NISE Net provided these participants with a variety of professional development and networking activities, including a total of 79 in-person professional development opportunities and 91 online workshops, guides, and training videos. NISE Net also created 203 public educational products, the majority of which freely available through the website for professional partners to implement and modify for their audiences and settings as needed through a Creative Commons license. In addition, a total of 1,654 physical NanoDays kits were produced and distributed to partner organizations over eight years (2008-2015) and 93 copies of the *Nano* exhibition were hosted by 149 museums and other ISE institutions around the US. It is estimated that these educational products and outreach efforts reached approximately 30.4 million members of the public between 2008 and 2015 (Evaluation #5: Svarovsky, Goss, & Kollmann, 2015).



The *Nano* exhibition

Nano is a small interactive exhibition that was built to engage family audiences in nanoscale science, engineering, and technology. Hands-on exhibits present the basics of nanoscience and engineering, introduce some real world applications, and explore the societal and ethical implications of this new technology.

The exhibition was designed to have a footprint of 400 square feet, and to fit into a variety of spaces on a museum floor. It consists of seven main components, including four panels (*What Happens When Things Get Smaller?*, *Where Can You Find Nano? I Spy Nano*, *What's New About Nano?*, and *What Does Nano Mean for Us*), the *Balance Our Nano Future* tippy table challenge, the *Small, Smaller, Nano* ferrofluid interactive component, and *Build a Giant Carbon Nanotube* hands-on activity. The exhibition also contains a *Static Beads* component and a seating area with a variety of nano-themed books, reading materials, and stuffed toys. Over the course of the project, 93 copies were made and distributed to partner sites. As of 2015, all copies were still on display to the public, though some had been transferred to new sites. Between 2012 and 2015, the exhibition was estimated to have reached over 23 million people (Evaluation #3; Svarovsky et al., 2013).



NanoDays

NanoDays was a nationwide festival focused on engaging the public in learning about nanoscale science, engineering, and technology. Founded by the NISE Network in 2008, NanoDays involved partner institutions in hosting programs and events during a particular week of the year, generally from the last weekend in March through the first weekend in April. Central to the event was the annual NanoDays kit, which typically contained around a dozen hands-on activities (including all necessary materials and supplies), posters, videos, planning and implementation guides, promotional and marketing materials, and staff and volunteer training materials. Partner institutions were encouraged to use materials beyond the event. As of 2015, over 7 million people had encountered NanoDays materials, whether during a NanoDays event or as part of other programming (Evaluation #5; Svarovsky et al., 2015).



NISE Net Professional Development Opportunities

NISE Net offered a range of professional development opportunities to increase individual professionals' capacity to engage public audiences in learning about nano. These included online and in-person gatherings focused on general nano concepts and public engagement practices, community-building opportunities, and professional development resources (such as videos and guides) that aligned with particular products. Some opportunities focused on increasing understanding of nano concepts; others emphasized specific practices such as universal design and engaging Spanish-speaking audiences; and still others focused on developing skills needed to implement NISE Net educational products, such as how to have conversations about nano and society or how to implement theater programs. While some professional development resources (e.g. training videos demonstrating new activities) were focused on one-way dissemination from the Network to their partners, others (e.g. Network-Wide, regional, and online meetings) were designed to allow partners to share their work and learn from others.

NISE Net Tier Structure

Because the number of partner institutions in NISE Net was so large, and the ways that they participated in the Network were so varied, Network Leadership categorized partner institutions into “tiers” that described the roles and responsibilities of the partner institutions, the ways they participated, and the kinds of NISE Net support they received. Over the course of the project, partner institutions sometimes moved between the tiers due to staffing changes, shifting institutional and Network priorities, and fluctuating levels of NISE Net activity. For Years 6-10 (2010-2015) of the Network, the tier definitions were as follows:

- **Tier 1—Core Partners:** These grant-funded partners operated the Network. Core partner institutions were charged with leading the field in raising public awareness, understanding, and engagement with nanoscale science, technology, and engineering. This included developing informal educational products, creating professional development opportunities, and building the capacity of Network partner institutions and professionals.
- **Tier 2— Nano-Infused Partners:** These institutions were the primary recipients of Network resources and professional development efforts, including regional workshops, online workshops, and Network-Wide Meetings. The Network actively worked to increase the capacity of nano-infused partners to deliver nano education experiences beyond NanoDays as an ongoing, sustainable part of their institutions’ programming.
- **Tier 3— Broad Reach Partners:** Institutions in this tier could take materials or ideas from the Network and use them in their own activities. The Network aimed to introduce nano informal education to Tier 3 organizations to the extent that these organizations could participate in, at least, some limited form of nano educational outreach such as participation in NanoDays. The Network used a publically accessible website and an open-source library of educational materials, as well as presentations at professional conferences to broaden the reach of nano education to these institutions.

A description of the Tiers can be seen in Figure 1. Additional information about the NISE Network can be found at: <http://www.nisenet.org/>

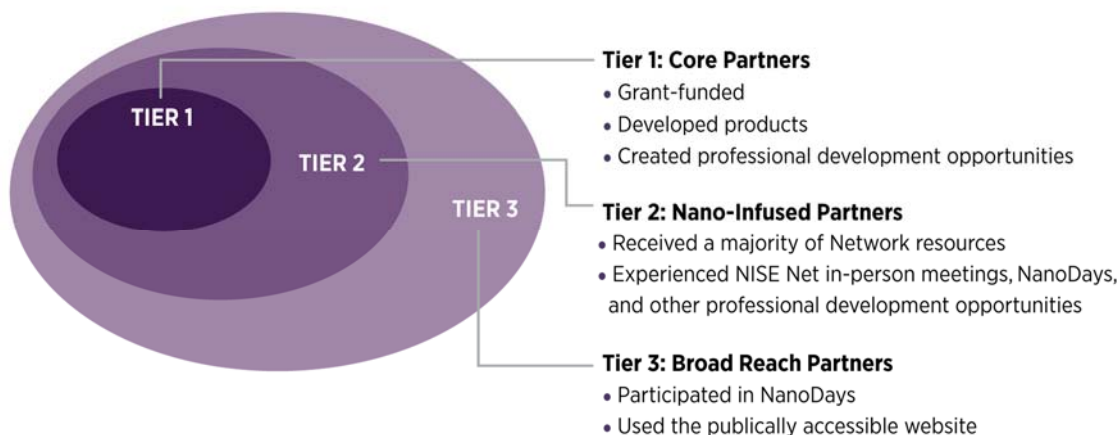


Figure 1. Description of the NISE Net Tier structure

NISE Net Goals and Logic Model

To guide the work for Years 6-10 of the project (2010-2015), NISE Network Leadership created a logic model for the Network. The logic model explained the strategies that NISE Net used to achieve its goals through two main strands of work:

- **Strand 1 – Network Community:** NISE Network → Builds a network community → Increases the field’s capacity to conduct nano programming → Engages the public in nano programming
- **Strand 2 – Educational Products:** NISE Network → Builds a network community → Creates educational products → Engages the public in nano programming

These strands of work are deeply interconnected. As stated in *Leading and managing the NISE Network: Practical solutions for creating a flexible national network* (Bell & Olney, 2017):

Through the collaboration of ISE organizations and research centers, the NISE Network would develop a national community. Through the national community, it would create an online catalog of educational products and provide professional development to raise the capacity of the field to engage the public in learning about nano. While some NISE Network products might reach the public directly, the key strategy was to work through ISE organizations and research centers to increase public awareness, understanding, and engagement with nano. In this way, the professional and public goals would be entwined. (p. 12)

A simplified version of the NISE Net Logic Model can be found in Figure 2. A copy of the full Logic Model can be found in Appendix A.

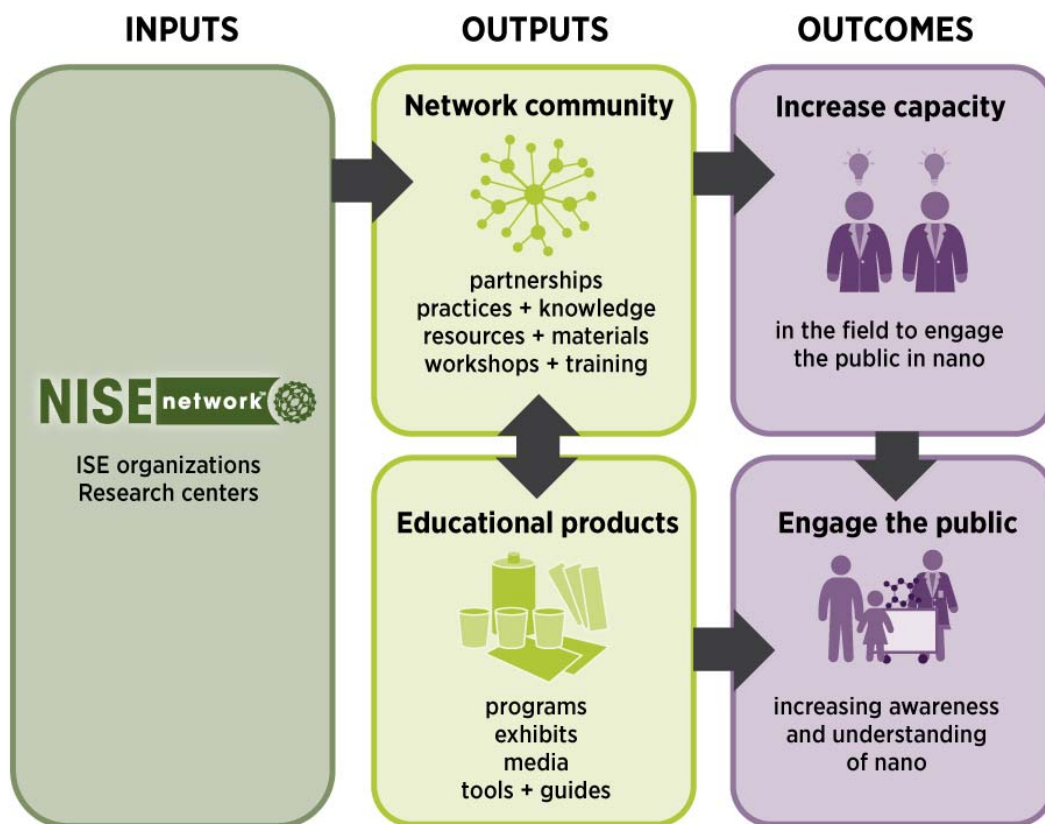


Figure 2. NISE Network simplified logic model

Through Years 6-10 of NISE Net, this logic model was used to set specific goals for the Network's public and professional audiences. These goals extended the logic model beyond how NISE Net would work to describing the kinds of outcomes and impacts that the Network was striving to achieve. The professional impact goals for NISE Net were that by participating in the Network, professionals would:

1. Identify with a broader community that includes scientists and museums.
2. Value local research-ISE collaborations.
3. Understand and appreciate key concepts in nanoscale science, engineering, and technology and its relationship with our lives, society, and environment.
4. Understand theories, methods, and practices for effectively engaging diverse public audiences in nano.
5. Utilize professional resources and educational products for engaging diverse public audiences in nano.

The public impact goals were that:

1. (Short term) Most visitors report increased awareness, knowledge, understanding, and engagement related to nano. Some visitors report changes in intended behavior related to nano.
2. (Medium term) Some visitors are more attentive to nano. A few visitors apply their knowledge and engagement in a social, economic, or educational context.
3. (Long term) Overall public awareness, knowledge, and understanding of nano increases. A few individuals become very engaged in nano (e.g. by seeking careers in the field).²

Evaluation in the NISE Network

Since its inception, evaluation has played a vital role in informing the work of the Network. Throughout the 10 years of the NISE Net nano project, 216 evaluation studies provided formative data to help inform the development of educational products, the planning and facilitation of professional development experiences, and the growth and expansion of the Network. Additionally, 24 evaluation reports provided summative data to help the Network and its stakeholders understand NISE Net's impacts on its audiences including partner professionals and the public.

NISE Net Evaluation in Years 1-5

In the first five years of NISE Net, a series of summative evaluations were conducted to understand the public and professional impacts of initial project efforts. The public impact evaluation studies focused on individual products such as a public dialogue and deliberation forum on nanomedicine, groups of products such as stage presentations or exhibits, and the public reach of the Network. Professional impact evaluation studies focused on how the NISE Network was forming and the awareness level of among ISE professionals about the Network. As stated earlier in this section, after the completion of the first NISE Net grant in 2009, two reports were written to summarize what was known about the impacts of the Network on its professional and public audiences. The *Overview of NISE Network Evaluation* report described “progress made in developing a network organization capable of supporting nanoscience education for the public on a national scale” (St. John et al., 2009, p. i). The *Review of NISE Net Findings: Years 1-5* (Reich et al., 2011) report summarized data collected about the public reach and impact of the NISE Network to inform the nano education work for Years 6-10 of NISE Net and the ISE field at-large.

² The long-term public goal was not expected to be achieved within the timeframe of the NISE Net project.

NISE Net Evaluation in Years 6-10

The focus of the Network shifted from building the network infrastructure and partnerships in Years 1-5 (2005-2010) towards utilizing the Network to engage the public in nano in Years 6-10 (2010-2015). Decisions about what to study as part of the Network evaluation during this phase of the project were based upon the impacts and outcomes described in the NISE Net logic model (see Figure 2 above). This meant that there was an emphasis on understanding the impact of the NISE Net on public and professional participants. Since the logic model and goals were applied across public deliverables, this allowed the evaluation studies to understand impacts across the different public educational products and have a greater understanding of overall impacts on the public. For professionals, this new focus meant that the Evaluation team looked at the impact of participation in the NISE Net as a whole on individual professionals instead of trying to understand the impact of individual professional development activities.

I. Methods

Years 6-10 Evaluation Studies

Because the logic model laid out the process for how the NISE Network would carry out its work and achieve its impacts, the Evaluation workgroup used the logic model to plan their summative evaluations beginning in Year 6. This meant that the evaluation ended up with two foci, as described in the Introduction. One focus was on understanding the impact of the Network on professionals. The second focus was on understanding the impacts of NISE Net's biggest deliverables on the public. In Years 6-10 (2010-2015), the Evaluation team conducted a number of studies about both of these strands of work to understand the extent to which NISE Net achieved their goals.³ Brief descriptions of the methods used to conduct these studies and the specific emphasis of each evaluation study can be found below. Also included are links to the full evaluation reports.

Evaluation study methods

The NISE Net Evaluation team conducted two kinds of summative evaluation studies as part of their Years 6-10 evaluation work. These methods were chosen to provide appropriate information given the data and evaluation needs of the Network and are described as follows:

- **Qualitative, descriptive studies:** At times, NISE Net needed information to better understand how professionals or publics were using Network products and practices. In these cases, evaluation studies used qualitative methods such as focus groups and interviews to generate rich descriptions and deep understandings of what was happening in the Network. These are summative studies #2 and #6, described below.
- **Mixed method, impact studies:** Other times, it was important for the Network to have understandings of how it was impacting its public and professional audiences through its products and practices. For these studies, evaluators used a mixture of quantitative methods such as surveys and timing & tracking as well as qualitative methods such as interviews and observations to draw conclusions about the ability of the Network to achieve its intended goals. In addition, data collected as part of these studies were also used to generate public reach estimates for NISE Net. These are summative studies #1, and #3-5, described below.

³ Evaluation findings from the NISE Net Museums and Community Partnerships supplement, implemented during project Years 11 and 12 (2015-2016), were not completed in time to be included in this report. The summative evaluation findings for that work are described in a separate report which can be found here: <http://www.nisenet.org/catalog/nise-net-museum-community-partnerships-project-summative-evaluation-report>

Descriptions of summative evaluation studies

To understand the impact of the Network on partner professionals, the Evaluation team conducted the following two summative evaluation studies:

1. The *NISE Network Professional Impacts Summative Evaluation* was a longitudinal examination of individual professionals over the final three years of the NISE Network. The study explored how involvement with NISE Net impacted an individual professional's sense of community, learning about nano, and use of nano educational products and practices (Goss, Auster, Beyer, Mesiti, & Kollmann, 2016).

<http://www.nisenet.org/catalog/nise-network-professional-impacts-summative-evaluation>

2. *A Study of Communication in the Nanoscale Informal Science Education Network* was conducted to understand how the four primary communication components that were developed in the first five years of NISE Net (NanoDays, face-to-face meetings, the regional hub structure, and the NISE Net website) functioned in communicating information, ideas, and practices related to NISE Net among Network partners (Alexander et al., 2012).

<http://www.nisenet.org/ncs>

Four summative studies focused on exploring the impact of the NISE Net's educational deliverables on the public. Three of these studies focused on individual deliverables while the fourth explored the overall impact of delivering many kinds of nano programming to the public. These studies include the following:

3. The *Summative Study of the Nano Mini-exhibition* was an evaluation of the *Nano* exhibition, a 400-square foot, modular exhibition that was replicated and installed initially at approximately 93 partner institutions and was installed at a total of 149 sites by the end of Year 10. This study sought to understand the estimated reach of the exhibition, whether the exhibition created an environment that encouraged engagement and learning for a broad public audience, and whether *Nano* complemented other nano learning experiences, including NanoDays (Svarovsky et al., 2013).

http://www.nisenet.org/catalog/evaluation/public_impacts_mini-exhibition_study_year_8_summative_evaluation

4. The *Summative Study of NanoDays 2014 Events* was an evaluation of spring 2014 NanoDays events. This study sought to understand: the estimated reach of NanoDays events in 2014; whether "mature" NanoDays events were successful in providing an engaging experience and promoting learning of nano concepts for public audiences, including event attendees and event volunteers; and whether volunteering at NanoDays

events had other impacts on volunteers, including increased interest in STEM activities/careers and confidence around engaging the public in nano (Svarovsky, Tranby, Cardiel, Auster, & Bequette, 2014).

<http://www.nisenet.org/catalog/summative-evaluation-study-nanodays-2014-events>

5. The *Public Reach Estimates for the NISE Network* was a summary of all of the major public reach estimates generated as part of the NISE Net evaluation studies. This report brought together the numbers about public reach gathered through the *Nano* exhibition, the *NanoDays* study, and information on kit use beyond NanoDays to describe the estimated overall public reach of the Network between 2008 and 2015 (Svarovsky et al., 2015).

<http://www.nisenet.org/catalog/public-reach-estimations-nise-network>

6. The *Summative Study of the Public Impacts of Nano-Rich Organizations* was a descriptive study of the richness of the Network's public offerings related to nanoscale science, engineering, and technology. Previous evaluation studies had documented the public reach and learning of particular NISE Net products, whereas the aim of this study was to describe how and to what extent NISE Net partner organizations provided multiple opportunities for members of the public to become aware of, engage with, and understand nanoscale science, engineering and technology (Guberman et al., 2016).

<http://www.nisenet.org/catalog/nise-net-public-impacts-nano-rich-organizations-summative-evaluation-2016>

Descriptions of Years 6-10 Research Studies

In Years 6-10, NISE Net also commissioned a series of research studies. The purpose of these studies was to look at different aspects of the Network that had the potential to inform the ISE field. Whereas the NISE Net evaluation studies measured progress toward Network goals, the research studies were designed to generate findings that would inform and advance the broader ISE field. While this report is not based on these studies, some of the findings from these studies are included in the Findings and Discussion sections to further elucidate findings from the summative evaluation reports.

Research studies #7–10 were funded directly by the NISE Network. However, additional funding was secured from NSF through the Promoting Research and Innovation in Methodologies for Evaluation (PRIME) solicitation to study evaluation capacity building in the Network (study #11 below). The NISE Net research studies include the following:

7. *Nano online: Tracking the NISE Net's Digital Footprint* was a study that examined online discourses about NISE Net-related work by tracking media coverage and discussions online. The purpose of the study was to have better understandings of how science centers and museums communicate with their stakeholders and various publics using social media tools, how the public attends to scientific discussions online, and the real world impacts that organizations can have on public communication of science (Scheufele & Su, 2015).

<http://www.nisenet.org/catalog/nise-network-research-nano-online-tracking-nise-net%E2%80%99s-digital-footprint>

8. *NISE Net Research on How Visitors Find and Discuss Relevance in the Nano Exhibition* was an exploratory study conducted on the *Nano* exhibition to understand how visitors use, interact with, and talk about the exhibit components within the exhibition to learn about the relevance of nano to their lives (Kollmann, Svarovsky, Iacovelli, & Sandford, 2015).

<http://www.nisenet.org/catalog/nise-net-research-how-visitors-find-and-discuss-relevance-nano-exhibition>

9. SRI Education completed two research studies focusing on how partnerships are formed and sustained between museums and university scientists:

a) *Partnerships in the NISE Net: A Study of Partnerships Between University Scientists and Museum Professionals* describes findings from research on NISE Net-supported partnerships between university scientists and museum professionals to educate the public about nano and focuses on understanding how scientists and museum professionals deal with challenges in partnering together, and how they ultimately leverage each other's perspectives and expertise when they collaborate to produce products intended to educate the public about nano (Lundh, Stanford, & Shear, 2015).

<http://www.nisenet.org/catalog/partnerships-nanoscale-informal-science-education-network-nise-net-study-partnerships>

b) *Nano and society: Case Study of a Research-to-Practice Partnership Between University Scientists and Museum Professionals* examined how complex and controversial science ideas are translated for the public through a research-to-practice partnership between university scientists and museum professionals. The study explored how collaborators leveraged each other's expertise and priorities to create professional development workshops and public educational products to engage the public in activities about the societal and ethical implications of nano (Lundh, Stanford, & Shear, 2014).

<http://www.nisenet.org/catalog/nano-and-society-case-study-research-practice-partnership-between-university-scientists-and>

10. *Research on Organizational Change in a National Network of Informal Science Education Institutions* employed a longitudinal case study approach to look at what organizational change among science museums and centers looks like as a result of participation in a national network and what factors facilitated or hindered change on an organizational level (Beyer, Guberman, & Iacovelli, 2017).

<http://www.nisenet.org/catalog/research-organizational-change-national-network-informal-science-education-institutions-2017>

11. *Complex Adaptive Systems as a Model for Network Evaluations* was a study that provided insights on (1) the implications of complexity theory for promoting widespread and systemic use of evaluation within a network, and (2) complex system conditions that foster or impede evaluation capacity building (ECB) within a network, in this case, within NISE Net (Lawrenz et al., 2016; see also King et al., 2015; Kollmann et al., 2016).

<http://www.informalscience.org/complex-adaptive-systems-model-network-evaluation>

How the Evaluation and Research Studies Relate to the NISE Network Goals

The table below indicates which evaluation and research reports from Years 6-10 of NISE Net provides information about the achievement of each of the professional and public impact goals. Each evaluation and research report is numbered in the table based on its number in the lists above. The first section is about the logic model strand 1 – related to network community and therefore the professional impact goals. The second section is about logic model strand 2 – related to educational products and therefore the public impact goals for the NISE Net. Each section lists the logic model outputs and impacts/outcomes for that strand of work. It also lists all of the studies that were completed in Years 6-10 about the NISE Net. An “X” indicates that the study provided information that helped the Evaluation team understand whether and how that goal was achieved (See Table 1 below).

Table 1. Evaluation and research studies that contribute to understanding the achievements of Strand 1 (Network Community) and Strand 2 (Educational Products) of NISE Net's logic model.

Outputs	Impacts/Outcomes <i>Professionals will...</i>	NISE Net Evaluation Studies						NISE Net Research Studies				CASNET	Total	
		1	2	3	4	5	6	7	8	9	10	11		
NISE Net fosters partnerships, generates practices and knowledge, creates resources and materials, and disseminates workshops and training.	1. Identify with a broader community that includes scientists and museums.	X	X								X			3
	2. Value local research-ISE collaborations.	X								X	X			3
	3. Understand and appreciate key concepts in nanoscale science, engineering, and technology and its relationship with our lives, society, and environment.	X								X				2
	4. Understand theories, methods, and practices for effectively engaging diverse public audiences in nano.	X	X								X	X		4
	5. Utilize professional resources and educational products for engaging diverse public audiences in nano.	X		X	X	X	X				X	X	X	8
	<i>Visitors will...</i>	1	2	3	4	5	6	7	8	9	10	11		
NISE Net creates programs, exhibits, media, tools, and guides.	(Short term) Most visitors report increased awareness, knowledge, understanding, and engagement related to nano. Some visitors report changes in intended behavior related to nano.			X	X	X	X	X	X					6
	(Medium term) Some visitors are more attentive to nano. A few visitors apply their knowledge and engagement in a social, economic, or educational context.				X				X					2

II. Findings

This section of the report presents a high-level summary of findings from across the evaluation and research studies described in the Introduction and Methods to provide evidence and insight into the overall impacts and outputs of the NISE Network. Organized by Network goal, the tables below indicate whether or not the various professional (Tables 2-6) and public goals (Tables 7 and 8) were met and include a summary about the type of evidence gathered for each one. Following each table is an expanded overview of the evaluation findings that support these claims. In addition, relevant findings from NISE Net research studies are described when appropriate to further illustrate the overall conclusions from the summative evaluation reports. The NISE Net goals, and thus these findings, have inherent connections between the professional and public impacts. Therefore, this section illuminates how the logic model for NISE Net played out in practice and provides useful background for the Discussion section.

Professional Goal #1: Build Community

Table 2. Summary of evaluation evidence and supporting studies for Professional Goal #1.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
Professionals will identify with a broader community that includes scientists and museums.	Yes	<p>Findings across multiple studies indicate that the Network succeeded in creating a sense of community among professionals from many types of organizations that varied in size and geographic location.</p> <p>NISE Net partners repeatedly reported that specific efforts by Network Leadership, such as offering meeting opportunities and providing easy access to resources, helped partners feel connected to each other and to the Network.</p>
	Supporting Evaluation Studies	
	<ol style="list-style-type: none"> 1. Professional Impacts 2. Network Communication Study 	

Across two different summative evaluation studies, findings support the conclusion that the Network met its goal of having partners identify with a broad group of professionals. From these efforts, it was clear that NISE Net created an extensive community by drawing in many different types of partners and organizations including 268 museums and science centers, 203 colleges and universities, and 127 other types of institutions, such as K-12 schools, libraries, and industry or government organizations. Within the partnering institutions, a variety of professionals, including informal science educators (ISE) and University-affiliated individuals, were engaged in NISE Net activities. University professionals included researchers and scientists, as well as education outreach coordinators and others who worked for a college or university. By the end of the Network, 2,709 professionals had been involved with the NISE Net (Evaluation #2: Alexander et al., 2012; Evaluation #1: Goss et al., 2016).

Overall, data show that partners felt as if they were part of a larger community, including scientists, university faculty and staff, as well as museum professionals. By Year 10, 77% of professionals identified “a lot” or “a great deal” with this community as opposed to 38% of professionals before they became involved with NISE Net (Evaluation #1: Goss et al., 2016). Findings from multiple studies indicate that the Network employed several successful mechanisms for encouraging feelings of community and interactions among these individuals. Strategies included a variety of in-person and virtual meetings, the regional hub structure, and the NISE Net website (Evaluation #2: Alexander et al., 2012; Evaluation #1: Goss et al., 2016). When responding to questions about the extent to which NISE Net allowed them to build connections with the Network, at least 90% of professionals agreed that NISE Net provided them with the opportunity to receive new educational materials for engaging the public in nano, learn from professionals outside of their organization, share with others about how they engage the public, and meet professionals from outside of their organization (Evaluation #1: Goss et al., 2016).

Research Study Connections. Research findings indicate additional factors that supported partner participation in the NISE Net community. Findings from the *Research on Organizational Change in a National Network of Informal Science Education Institutions (Research on Organizational Change)* study show that alignment of goals played a crucial role as to whether or not museums were motivated to participate in and felt they could meet their needs by taking part in the Network. Alignment between NISE Net’s products/activities and the museums’ goals and typical practices facilitated the use of Network resources. This alignment meant that museums were able to easily incorporate NISE Net products into their work and be active members in the community (Research #10: Beyer et al., 2017).

Professional Goal #2: Value Collaborations

Table 3. Summary of evaluation evidence and supporting studies for Professional Goal #2.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
Professionals will value local research-ISE collaborations.	Yes	<p>Findings from a longitudinal study show that partners reported new and often ongoing collaborations created due to NISE Net. In particular, NanoDays events commonly functioned as catalysts for partnerships that continued over time.</p> <p>Confidence in and evidence of partnering along with use of resources were measures of whether or not professionals valued local research-ISE collaborations. Year 10 data indicate that, in general, professionals had high levels of confidence in starting partnerships, were collaborating with others around nano and non-nano topics, and using relevant NISE Net resources.</p>
	Supporting Evaluation Studies	
	1. Professional Impacts	

The *NISE Network Professional Impacts Summative Evaluation (Professional Impacts)* study provides evidence the Network achieved its goal to have professionals’ value local research-ISE collaborations. Evaluation findings illustrate that in Year 10, 75% of professionals responded in the top two levels of agreement when asked about their confidence to start a partnership with an informal learning or research organization. When specifically looking at ISE professionals’ confidence over Years 8-10, there is evidence that professionals became significantly more confident in their abilities to start a collaboration by the end of the Network. Data from interviews indicate that NanoDays and NISE Net resources were useful for increasing ISE professionals’ comfort in this work (Evaluation #1: Goss et al., 2016).

NISE Net encouraged partnering between researchers and ISE organizations, and in Year 10, 78% of professionals reported that their organization had partnered or collaborated with another around engaging the public in nano. Of those who had nano-related partnerships, 71% indicated they had between one to five collaborators in the last year and that this typically included a university/college. On the same survey, 83% of professionals reported that NISE Net had at least “somewhat” increased their organization’s partnerships or collaborations on any topic, nano or otherwise. The Network’s investment of resources toward partnership development and its signature event, NanoDays, were cited as important reasons why collaborations were established and often continued over several years. Of the professionals who reported initiating a partnership, 79% of the professionals said they used a NISE Net resource in these efforts (Evaluation #1: Goss et al., 2016).

Research Study Connections. Research studies suggested several factors that helped facilitate partnerships. They also underscored how there can be challenges to working with individuals at different organizations. Like the *Professional Impacts* evaluation, the *Research on Organizational Change* study indicates that NanoDays was a catalyst for partnering. In terms of reasons why this event may have been so successful for facilitating partnerships, this study found that not only did museums and partners often have shared goals, but they felt NanoDays allowed them to participate in mutually beneficial work. Moreover, the repeating nature of the event helped enable ongoing relationships. However, data suggest difficulties sometimes arose in maintaining partnerships when there was staff turnover or were communication issues (Research #10: Beyer et al., 2017).

The research study, *Partnerships in the NISE Net: A Study of Partnerships between University Scientists and Museum Professionals (Partnerships in the NISE Net)*, also identified the importance of common goals and personal connections in aiding collaborative work. When highlighting challenges that museum professionals and scientists ran into when trying to partner together, this research noted that different terminology, conflicting notions of outreach, and differing “values and practices in their respective professional fields” played a role (Research #9a: Lundh et al., 2015, p. 1).

Professional Goal #3: Learn About Nano

Table 4. Summary of evaluation evidence and supporting studies for Professional Goal #3.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
<p>Professionals will understand and appreciate key concepts in nanoscale science, engineering, and technology and its relationship with our lives, society, and environment.</p>	Yes	<p>Findings from a longitudinal summative evaluation indicate that Network partners demonstrated gains in their understanding of and confidence in explaining different areas of the NISE Net content map, suggesting that they learned about nano as they participated in the Network.⁴</p> <p>In particular, NISE Net emphasized the societal and ethical implications of nano as one of the main concepts that partners could learn about and share with public audiences. Data indicate that the professionals specifically targeted by the Network (those in Tier 2 and those working in ISE organizations) reported positive change over time, especially concerning these particular concepts.</p>
	Supporting Evaluation Studies	
	<p>1. Professional Impacts</p>	

⁴ The following nano concepts were used to understand learning as a part of the *Professional Impacts* evaluation because they align with the four areas of the NISE Network Content Map.

- The size of a nanometer.
- How nano-sized materials behave compared to macro-sized materials.
- How scientists work at the nanoscale.
- Examples of nano in nature.
- Innovations that are possible because of nanotechnology.
- Ways that nanotechnology improves existing products.
- Risks or potential risks of nanotechnology.
- How the future of nanotechnology may be influenced by political, economic, and personal values.

Evaluation data indicate that NISE Net succeeded in helping professionals gain knowledge of nano concepts. By the end of the Network, the majority of professionals reported they were confident in explaining all of the nano concepts to other adults and credited NISE Net with affecting this confidence. Although Tier 2 and ISE professionals were more likely than Tier 3 or University partners to attribute NISE Net with impacting their confidence in nano, various resources and NISE Net opportunities were noted by all as being useful for learning about these topics. These resources included NanoDays kits, face-to-face meetings, and the Network's website (Evaluation #1: Goss et al., 2016).

NISE Net specifically helped professionals understand connections between nano and society. When looking at findings that include all professionals, it is clear that by the end of the Network over 65% felt NISE Net had affected their confidence "a lot" or "a great deal" in terms of being able to explain concepts related to nano and society. However, Tier 2 and ISE professionals, on whom the Network had focused their professional development opportunities and resources, experienced the following increases: significant gains over Years 8-10 in confidence explaining nano and society concepts and attributing this confidence to NISE Net (Evaluation #1: Goss et al., 2016).

Research Study Connections. The *Nano and Society: Case Study of a Research-to-Practice Partnership (Nano and Society: Case Study)* analyzed how university scientists and museum professionals worked together to incorporate nano and society concepts into NISE Net's products. This research showed how NISE Net moved away from creating experiences that would primarily communicate the risks and benefits of nano technology to offering opportunities where visitors could talk about their views on the role of nano and technology. The case study highlights how this shift in approach influenced the creation of various guides, workshops, and other supports to help professionals better understand how to engage with visitors in conversations about the role of nano in society. The research also noted various factors that facilitated university scientists and museum professionals in being able to work together to create activities that addressed a controversial topic like nano and society. These factors included having common goals among the partners, the support of their respective institutions to participate in this type of work, an appreciation of each other's expertise, and strong working relationships that often grew out of early face-to-face meeting opportunities (Research #9b: Lundh et al., 2014).

Professional Goal #4: Learn About Practices

Table 5. Summary of evaluation evidence and supporting studies for Professional Goal #4.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
Professionals will understand theories, methods, and practices for effectively engaging diverse public audiences in nano.	Yes	Findings from multiple evaluation studies show that Network partners demonstrated gains in their understanding and fluency with a range of methods and practices related to engaging diverse audiences in nano, suggesting that they increased their abilities in these areas as they participated in the Network. Confidence in and use of practices along with awareness of resources were measures of professionals' familiarity with the practices that NISE Net encouraged among partners. ⁵ While some practices were not being used as frequently as others, for all but one (engaging Spanish-speaking audiences), the majority of professionals reported implementing them with the public.
	Supporting Evaluation Studies	
	1. Professional Impacts 2. Network Communication Study	

⁵ The following public engagement practices were identified in collaboration with NISE Net Leadership to represent the theories, methods, and practices encouraged by the NISE Net. These were used in the *Professional Impacts* evaluation as a way to determine whether or not this goal was met.

- Engaging young children.
- Engaging adult audiences.
- Engaging Spanish-speaking audiences.
- Applying principles of universal design.
- Engaging audiences with nano and society content.
- Using team-based inquiry to incorporate evaluation into my work.
- Communicating to a public audience findings from the field of nano research.

There is one additional practice that deals with initiating a partnership with an informal learning or research organization. See the finding section on Professional Goal #2 for information about this practice.

Evaluation data show that the Network met the goal of giving professionals familiarity with a range of practices for engaging the public in nano. In particular, over 75% of professionals “mostly” or “completely agreed” that they were confident about engaging young children, engaging adults, engaging audiences with nano and society content, and communicating nano research findings to the public. For the other practices, the majority of professionals responded in the top four of six response categories for their confidence. However, findings show that professionals were using some practices more than others. In particular, they were more likely to be engaging young children and adult audiences as well as engaging audiences with nano and society content or communicating findings from nano research than applying universal design, implementing Team-Based Inquiry (TBI), or engaging Spanish-speaking audiences. For these practices, partners indicated barriers such as lack of time/resources, lack of knowledge or misconceptions, and the fact that this work did not align with their professional role or their organization’s goals as reasons for not using them as a part of their work. Nonetheless, interview data showed that these barriers, especially for nano and society content, sometimes diminished for professionals over time due to exposure to NISE Net resources that were designed to showcase this content in an accessible way (Evaluation #1: Goss et al., 2016).

There is evidence that NISE Net-related experiences and resources were useful for professionals to learn about the Network’s strategies for carrying out nano with diverse public audiences. Professionals especially described the impact of face-to-face meetings and NanoDays in helping them gain confidence in engaging the public in nano (Evaluation #2: Alexander et al., 2012; Evaluation #1: Goss et al., 2016). Evaluation findings also indicated that NISE Net resources were used by 77-94% of professionals who reported implementing the various public engagement practices (Evaluation #1: Goss et al., 2016).

Similar to Goal #3, evaluation findings show that professionals who were targeted by the Network’s opportunities and resources, such as Tier 2 and ISE professionals, had significant gains in confidence and use around some of the practices. Over Years 8-10, both of these groups became more confident in engaging adult audiences and Spanish-speaking audiences and increased their audience engagement around nano and society content (Evaluation #1: Goss et al., 2016).

Research Study Connections. Research suggests various conditions that are needed in order for the practices encouraged by the Network to become part of an individual’s or organization’s on-going work. The *Research on Organizational Change* study found that museums had difficulties implementing and sustaining some of the practices, such as engaging audiences with nano and society content, incorporating evaluation, or using new ways to engage visitors. While enthusiasm was often high, these practices did not always align with museums’ goals. Other barriers such as a lack of time or the departure of important advocates for this work also impacted whether or not they were integrated into the work of an organization. Nonetheless, this research did show evidence of how the practice of applying

universal design was incorporated into a museum's work. Through a particular case study, it was found that shared goals, opportunities to put these ideas to use, and joint work surrounding these concepts allowed for on-going integration of universal design (Research #10: Beyer et al., 2017).

Research from the *Complex Adaptive Systems as a Model for Network Evaluations (CASNET)* study also indicates several conditions that need to be in place for TBI to spread. TBI is a process of practitioner-led inquiry or evaluation that was developed and shared across the Network beginning in Year 6. It was designed to allow practitioners to get the data they needed, when they needed it to make changes to products. Crucial for TBI was having teams of people to conduct this work together within an institution. It was also important that there be coherence and redundancy among individuals' skills, knowledge, and understandings of the value of evaluation to build consensus about the work. Diversity among individuals' skills and knowledge was also necessary to allow for new ideas and directions to come into the work and to make it relevant to participants. Finally, the *CASNET* study found that that there needed to be both centralized control, or support from organization leaders, but also decentralized control, or practitioner decision making, to encourage the use of TBI (Evaluation #11: Lawrenz et al., 2016).

Professional Goal #5: Use Resources to Engage the Public

Table 6. Summary of evaluation evidence and supporting studies for Professional Goal #5.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
Professionals will utilize professional resources and educational products for engaging diverse public audiences in nano.	Yes	Findings from several studies suggests that Network partners not only regularly and frequently used the educational products and resources of the NISE Net, but also modified and adapted activities to their specific contexts.
	Supporting Evaluation Studies	Across multiple studies and reports, Network partners indicated that some NISE Net products (e.g., cart demos and hands-on activities, media, and classroom activities) were used more often than others (e.g., science cafes, museum theater, or forums).
	<ol style="list-style-type: none"> 1. Professional Impacts 3. Nano Mini-exhibition Summative 4. NanoDays Summative 5. Public Reach Estimations 6. NanoRich Summative 	Over a 10-year span, ISE professionals' ongoing use of NISE Net educational products helped the Network reach over 30 million people across the United States.

The *Professional Impacts* study suggests that NISE Net met this goal in a variety of ways. Professionals were more likely to do nano with the public after participating in NISE Net than before, with 82% saying they currently engaged the public in nano in their current role as opposed to 31% who had done so prior to getting involved. These efforts often occurred throughout the year as well as at NanoDays events, with 65-84% of professionals reporting that they used NISE Net cart demonstrations and hands-on activities, media, and classroom activities. Moreover, professionals often adopted or created their own related resources or nano programming. In general, NISE Net resources were more likely to be used to implement the public engagement practices related to engaging young children, engaging adults, conveying nano and society content, and communicating nano research findings (Evaluation #1: Goss et al., 2016).

Beyond the evidence provided for this goal by the *Professional Impacts* study, the *Public Impacts* studies (*Nano Mini-exhibition Summative*, *Nano Days Summative*, *Public Reach Estimates*, and *Nano-Rich Summative*) also contribute data that triangulate these findings in meaningful ways. Across all four of the *Public Impacts* studies, data on the number and type of nano-content learning opportunities that were made available to the public via NISE Net indicated that professionals did indeed utilize Network resources and products in a variety of ways to engage a wide range of audiences in nano. Specifically, the *Public Impacts* studies provide some evidence of different audiences (such as children’s museum visitors, Hispanic visitors, and visitors with disabilities) successfully engaging with NISE Net products in several institutions across the Network (Evaluation #6: Guberman et al., 2016; Evaluation #3: Svarovsky et al., 2013). Moreover, the *NanoRich Summative* evaluation provides a snapshot of the kinds of public offerings related to nano that occurred within NISE Net partner institutions, which demonstrates the broad spectrum of opportunities that have been made available to public audiences through the Network’s efforts. Findings from this study show that various types of organizations offered multiple ways for visitors to participate in nano over the course of a visit (Evaluation #6: Guberman et al., 2016).

Research Study Connections. Research findings provide further evidence for the various ways that products and resources were used by professionals and organizations and some of the reasons why. For example, findings from the *Research on Organizational Change* study illustrate that museums increased their nano programming in a variety of ways especially through exhibits and programs. The kits were useful for programming, but, overall, nano exhibits often led to long-lasting changes because they were incorporated into permanent collections, aligned with organizational goals, and were less vulnerable to programmatic barriers such as modifications to daily schedules (Research #10: Beyer et al., 2017). Additional studies also indicate that NanoDays materials were created to be accessible to visitors, which facilitated their broad use (Research #9a: Lundh et al., 2015) . In addition, some Network partners were shown to be actively using other practices developed by NISE Net – such as Team-Based Inquiry and Universal Design practices - to help them engage their audiences in nano (Research #10: Beyer et al., 2017; Research #11: Lawrenz et al., 2016) .

Moving From Professional Impacts to Public Impacts

Looking across the body of evidence summarized in the sections above, the extent to which NISE Net was able meet its professional goals is clear. Over a 10-year period, ISE professionals and university partners formed a vibrant network community, collaborated with each other on both NISE Net and non-NISE Net related projects, made significant gains in their understanding of nano and their knowledge of how to communicate nano to diverse publics, and ultimately engaged substantial numbers of people in NISE Net activities. The next two sections describe the range of public impacts achieved by the Network, as determined by a set of four *Public Impacts* evaluation studies conducted in Years 6-10 of the NISE Net.

Public Goal #1: Increase Awareness and Engagement

Table 7. Summary of evaluation evidence and supporting studies for Public Goal #1.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
<p>Most visitors will report increased awareness, knowledge, understanding, and engagement related to nano. Some visitors will report changes in intended behavior related to nano.</p>	<p>Yes</p>	<p>Findings from various studies suggests that members of the public who engaged with NISE Network educational products increased their understanding related to nano, as demonstrated by increases in confidence talking about nano, describing nano to others, and finding connections between nano and their daily lives.</p>
	<p>Supporting Evaluation Studies</p>	
	<p>3. <i>Nano</i> Mini-exhibition Summative</p> <p>4. NanoDays Events Summative</p> <p>5. Public Reach Estimates</p> <p>6. NanoRich Summative</p>	

The *Public Impacts* studies provide ample evidence in support of this Network goal. In particular, the studies include specific explorations of how the public increased their awareness, knowledge, understanding, and engagement related to nano due to their participation in the *Nano* exhibition as well as NanoDays events (Evaluation #3: Svarovsky et al., 2013; Evaluation #4: Svarovsky et al., 2014).

Members of the public who visited the *Nano* exhibition across a range of representative partner organizations demonstrated an increase in their confidence around talking about nano, describing nano concepts, and finding connections between nano and their daily lives. In addition, almost all visitors reported high levels of interest and enjoyment for themselves (95% and 96%) and for the children in their group (79% and 87%). Visitors who used the *Nano* exhibition most often did so in groups (87% of the time based on observations), and across all ages (Evaluation #3: Svarovsky et al., 2013). Each of these indicators suggest that a

wide range of visitors were able to engage with the *Nano* exhibition, suggesting a high level of engagement with the exhibition and the nano content embedded within it.

In addition, members of the public who attended NanoDays events at a range of representative partner organizations demonstrated a statistically significant increase in these same areas: confidence around talking about nano, describing nano concepts, and finding connections between nano and their daily lives (Evaluation #4: Svarovsky et al., 2014). The two largest effect sizes were seen in visitor responses about how nanoscale objects behave differently than other objects (Cohen's $d = 0.42$) and identifying at least two factors to consider when thinking about using new nano products or nanotechnologies (Cohen's $d = 0.41$).

Research Study Connections. The NISE Net *Research on How Visitors Find and Discuss Relevance in the Nano Exhibition (How Visitors Find and Discuss Relevance)* research study suggested that at least for some visitors who engaged with the *Nano* exhibition, it helped them to understand the connection between nano and their everyday lives (Research #8: Kollmann et al., 2015). Visitors who were interviewed as part of this study reported that they made connections between these areas while engaging with a range of exhibit components – but in particular, connections were made at the exhibit panels where images and text described the presence of nano in society and nano applications. In addition, another research study, *Nano Online: Tracking the NISE Net's Digital Footprint*, used a complex online algorithm to find mentions of NISE Network and nano-related keywords on major social media websites. Spikes in nano-related mentions did appear to coincide with scheduled NanoDays activities, which could suggest a digital type of engagement and awareness development around nano (Research #7: Scheufele & Su, 2015).

Public Goal #2: Increase Attentiveness and Application

Table 8. Summary of evaluation evidence and supporting studies for Public Goal #2.

Statement of Network Goal	Was this goal met?	Summary of Evaluation Evidence
<p>Some visitors will be more attentive to nano. A few visitors will apply their knowledge and engagement in a social, economic, or educational context.</p>	Yes	<p>Findings from a summative evaluation study demonstrate that NanoDays volunteers, who had deeper engagement with nano than the general public, showed larger increases in confidence around talking about nano and describing nano to others.</p> <p>Young volunteers (high school juniors/seniors and early undergraduate students) also reported increased interest in STEM activities and careers after engaging in NanoDays.</p>
	<p>Supporting Evaluation Studies</p>	
	<p>4. NanoDays Events Summative</p>	

The *Public Impacts* studies provided several pieces of evidence in support of this goal including the motivations and experiences of NanoDays volunteers, or members of the public who contribute their various skills and talents by presenting and taking on other tasks as a part of NanoDays events throughout the country. In 2014, it is estimated that there were nearly 5,000 NanoDays volunteers engaged throughout the Network (Evaluation #4: Svarovsky et al., 2014).

Findings indicate that NanoDays volunteers, like NanoDays event attendees, had a statistically significant increase in their confidence around talking about nano, describing nano concepts, and finding connections between nano and their daily lives (Evaluation #4: Svarovsky et al., 2014). Once again, the two largest effect sizes were seen in volunteers' responses about their confidence in describing one example of how nanoscale objects behave differently than other objects (Cohen's $d = 0.48$) and identifying at least two factors to consider when thinking about using new nano products or nanotechnologies (Cohen's $d = 0.49$). These effect sizes are larger than those for the event attendees indicating greater learning for the NanoDays volunteers. In addition, NanoDays volunteers reported statistically

significant increases in their confidence around practices related to engaging the public in new and current science (Evaluation #4: Svarovsky et al., 2014).

Furthermore, almost a quarter of the NanoDays volunteers who participated in the 2014 Volunteer Survey indicated that they were return volunteers, suggesting that NanoDays provided ongoing engagement in a specific nano educational context. In addition, high school and early college-level volunteers demonstrated an increase in STEM careers and activities after engaging in a NanoDays event experience (Evaluation #4: Svarovsky et al., 2014).

Research Study Connections. The *How Visitors Find and Discuss Relevance* study also provided some evidence that visitors became more attentive to nano after engaging with the *Nano* exhibition. The study explored different ways that visitors made connections and found relevance throughout their experience with *Nano*. This study showed that visitors could make these connections in different ways, such as finding relevance within exhibit text or images or bringing in experiences from their own lives that connected with an idea in the *Nano* exhibition. In addition, the study began to explore the mechanisms for forming this relevance, and the data suggests that exhibit panels and interactives can function in different ways to help visitors form these points of relevance (Research #8: Kollmann et al., 2015).

Summary of Findings: One Network, Many Impacts

The findings presented in this section provide a high-level summary of the different impacts achieved by the NISE Network during a 10-year period. Building on the organizing framework of the NISE Net Logic Model, Network Leadership identified professional and public goals that guided Network efforts and decision-making. The evidence shared throughout this section suggests that the Network was able to meet each of these goals in various ways, as seen through the wide and continued use of NISE Net products, the collaborations and community that have been catalyzed by NISE Net, and the increases in confidence and understanding of both ISE professionals and the public around nano. Ultimately, the Network engaged over 2,700 professionals in its work, reaching over 30.4 million people through its educational products and outreach efforts over a 10-year span (Evaluation #5: Svarovsky et al., 2015).

Certainly, engaging Network partners in achieving this public reach relied on a variety of factors. Some of these factors were highly intentional and put in place by Network Leadership; others were more of a confluence of conditional, societal, and environmental factors that came together to prime the ISE field for the initialization and growth of the NISE Net. In the following Discussion section, we attempt to interpret the evidence presented in this Findings section by making connections between professional impacts, public impacts, and the NISE Net logic model described above.

III. Discussion

As described in the Introduction, in Years 6-10, the Network directions were decided, in part, by a logic model (see Figure 3 and Appendix A). In the logic model, one of the main outputs of the Network was to bring together organizations and professionals with different disciplinary backgrounds, participant populations, ambitions, and perspectives on and experiences with science, nano, and education to create a *community* with a shared purpose and set of practices around informal nano education. Over the course of the project, this community also created a large body of shared work, developing *products* that the Network community chose to use broadly to reach many public audiences.

The final outcomes of the project as described in the logic model fall into two major categories: the *increased capacity* of professionals in the community to understand nano and informal science education practices, and the *public engagement* done by that group, using the products developed through the course of the project to engage the public in learning about nano.

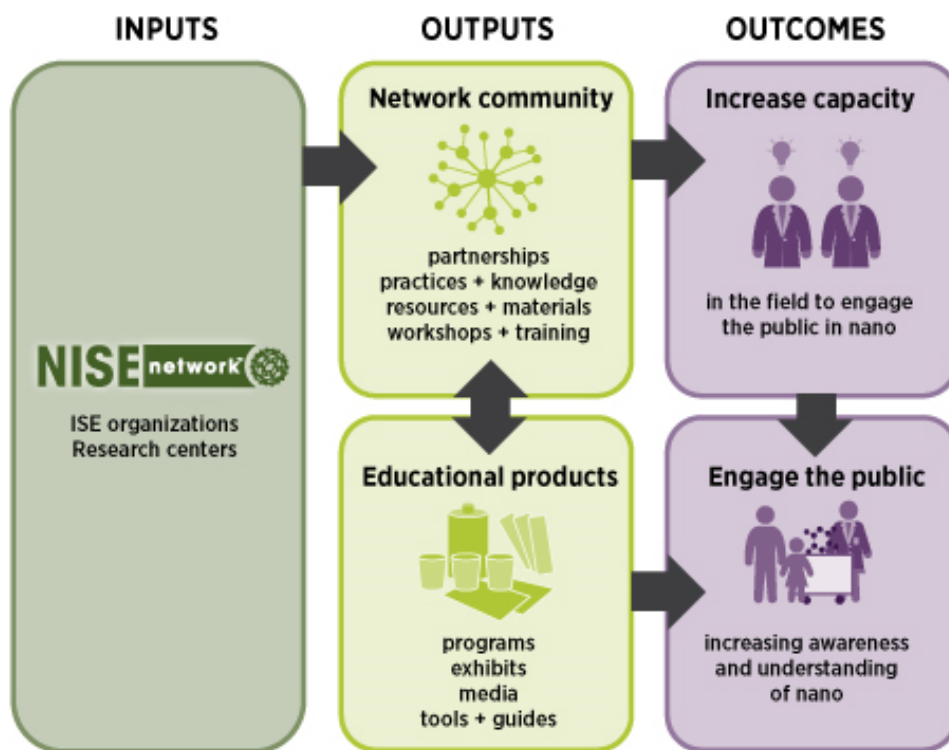


Figure 3. NISE Network simplified logic model

Because the logic model was used to inform both the deployment of resources and the shape of the evaluation in Years 6-10, it serves as a useful way to explore the project outcomes in a discussion of what contributed to the Network meeting its goals. For both the professional and public outcomes to be met as described in the Findings section, professionals needed to engage in learning about nano and educational practices as well as commit to using educational products at high rates. A closer examination of the Network outputs and inputs from the logic model, as well as the specific conditions and contexts encountered by the Network provides helpful insights on the mechanisms and decisions employed by the NISE Net to achieve its goals of broad reach and impact.

As described in the Introduction, the two strands of work in the Logic Model highlighted 1) Network Community and 2) Educational Products. These strands, as seen below, were presented as a simplified view of the Network's logic model:

Strand 1, Network Community: NISE Network → Builds a network community
→Increases the field's capacity to conduct nano programming → Engages the public in nano programming

Strand 2, Educational Products: NISE Network → Builds a network community →
Creates educational products → Engages the public in nano programming

These strands of work were carried out in an integrated manner, but articulating them succinctly and separately helped organize and guide the work of NISE Net in productive ways. In the next section, key activities and outputs that contributed to each strand of work are discussed in an effort to better understand and contextualize the outcomes of the Network.

Evidence for these outcomes are largely derived from the evaluation studies described above, but a certain degree of interpretation is provided that emerged from the evaluators' observation and participation in the network over these five years. The Evaluation team attended project meetings, large and small, listened to partners, and saw how Leadership articulated and used this logic model, all of which provided insight into not just what happened, but why it may have happened that way.

Interpretation of evidence supporting “Strand 1: Network Community”

For the NISE Net's first strand of work, the main objectives were to build a Network community and to increase the field's capacity to conduct nano programming so that NISE Net could reach a large segment of the public. This section will highlight the one or two main factors that contributed to each step of Strand 1. Though not a complete list, evidence of the

activities, outputs, and inputs that are the most plausible contributors to the outcomes observed among professionals participating in the NISE Net are described below.



What aspects of NISE Net contributed to building a Network community?

Organizational structure and guiding frameworks

Evidence suggests that the strong structure the Network established, with regard to its organizational configuration and core frameworks, was fundamental to building community. NISE Net created an organizational structure that allowed work to be accomplished across the 14 institutions that comprised Tier 1. These structures included having a central Leadership team as well as various workgroups consisting of cross-institutional members. The workgroups were able to lead distinct aspects of the Network's activities, such as the design of the *Nano* exhibition, development of the website, creation of the annual NanoDays kits, and more. Furthermore, the Network had Regional Hub Leaders located throughout the country that provided consistent support to partners in different geographic regions. These Regional Hubs were able to act as a mechanism for disseminating information and building community with partners of all tiers. The hub structure allowed partners to have interactions with NISE Net staff by email, over the phone, through informal meetings, and at specific regional and Network-Wide Meetings. These regional opportunities also allowed peers to see what other institutions in their area were doing in regards to nano. In addition to the help of Regional Hub Leaders, the Network devised other ways to disseminate information to organizations in Tier 2 and beyond. These mechanisms included processes for awarding kits, mini-grants, and other products; in-person gathering and online workshop opportunities that brought professionals together; as well as updates to partners through a monthly e-newsletter, social media, email, and the website.

By Year 6, underlying the organizational structure of the Network was a set of core principles that provided framing for engaging the public in nano. Based on the logic model, the main documents which helped provide the foundation for the work of the Network included a content map which outlined the four central ideas for the content of NISE Net's educational products and documents specifying professional development goals and practices (see Appendix B). The ideas in these documents helped guide the creation of the Network's product and professional development offerings and were embedded into the products in a myriad of ways. For instance, the NanoDays kits offered a variety of activities that touched upon the main content areas while at the same time provided concrete examples of how to effectively engage a range of audiences in STEM. Not only was the content placed in several activities, but specific guides, training videos, and instructional sheets provided additional

support to help practitioners implement this fairly new science topic with a range of audiences. These documents provided a clear vision for what the Network saw as high-quality nano educational efforts and helped drive the work of the core group of partners who created NISE Net products. Evaluation findings indicate that the best practices for public engagement embedded within the NISE Net activities, at times, served as models for Network partners in the development of their own educational products on other topics (Evaluation #1: Goss et al., 2016).

Inclusive and flexible philosophy

In order to build a community, NISE Net needed more than an organizational structure and core frameworks. It also needed to be inclusive and flexible enough to meet the needs of a diverse range of partners. A guiding principle of the NISE Net was that learning about nano content could be for everyone, and the Network was therefore very welcoming to a range of organizations within all tiers of the Network. While there were limits to eligibility for the physical resources and meeting attendance,⁶ ultimately, the Network grew to include organizations of differing sizes, annual budgets, geographic locations, and audiences. Of the 598 organizations that comprised the Network by 2015, partners included 203 colleges and universities, 268 science centers and museums, as well as 127 additional organizations such as libraries, K-12 schools, and government and industry institutions (see Figure 4). The diversity of organizations and their enthusiasm to incorporate nano in ways that were appropriate for their settings encouraged the NISE Net to create products for a wide range of ages and interests. Evaluation findings show that professionals from these varied types of organizations often referred to how useful the Network's structure, such as Regional Hubs, or other efforts to bring professionals in contact were for making them feel part of the Network (Evaluation #1: Goss et al., 2016).

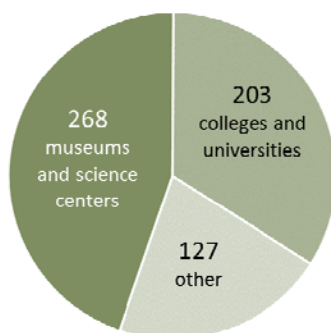


Figure 4. By the end of Year 10, the Network involved organizations of many sizes and types.

Moreover, the fact that the Network emphasized to partners that they should feel free to customize this work and adapt it for their settings also helped the NISE Net build a strong community. Because the majority of the NISE Net's products (including instructional guides

⁶ Everyone had access to the digital resources on www.nisenet.org.

and supporting materials) were online and available under a Creative Commons license, professionals were able to use these resources and their knowledge to modify or design their own programs around nano. Thus, while the Network offered suggestions in terms of how to facilitate the various activities and implement them as designed, the NISE Net's open-source philosophy meant that partners were also encouraged to adapt the resources according to their needs. For example, partners were able to modify, combine, and build onto the physical products as well as the downloadable resources offered by the NISE Net in order to align with their organization's typical programming and branding formats.

Evaluation findings show that because of these efforts, partners were able to take part in the NISE Net community while simultaneously meeting their own missions and priorities. Children's museums, for example, could take the materials and modify them for very young audiences while university partners, at times, even used the materials with students in their classes (Evaluation #1: Goss et al., 2016). Yet, it is important to note that because the Network had embedded the core principles related to content and engaging audiences in a variety of ways, even if partners adapted the materials and used the aspects that worked best for them, there was still a shared vision related to engaging the public in nano. When asked an open-ended question about their nano learning goals for visitors, staff at organizations that were deeply engaged in the project reported goals that closely aligned with the content map (Evaluation #6: Guberman et al., 2016). Overall, the core frameworks and the emphasis on flexible implementation provided the NISE Net community with a common structure for engaging the public in nano as well as the ability to make modifications to STEM educational materials that aligned with their own work and setting. Together, the defined yet welcoming structure of NISE Net allowed many diverse professionals and organizations to contribute and take part in the Network.



What aspects of NISE Net contributed to building the capacity of the field to conduct nano programming?

Products that modeled best practices and provided additional information

NISE Net's products and professional development opportunities were two supports that allowed Network partners' to increase their capacity to engage the public in nano. The design of the educational resources facilitated not only the use of the materials by many partners, as we will see in the section on Strand 2, but also the professional development of staff who interacted with these products.

The whole suite of NISE Net materials, from NanoDays kit activities to various guides and resources, were aimed at conveying nano content and best practices⁷ to help professionals engage a range of audiences (see Figure 5). The inclusion of this information made it very easy for partners to use the materials and to learn new techniques for engaging with the public and their peers. NISE Net, for example, designed the NanoDays kits to be accessible to a range of audiences and have entry points for people of varied ages, languages, and abilities. If facilitators wanted more information about the content, the kit included additional explanations and also pointed people to the NISE Net website to see training videos explaining how to facilitate each activity. Specific guides and other supporting materials taught professionals about public engagement practices that were often new to many partners, such as how to convey nano and society content or how to conduct an evaluation or Team-Based Inquiry in order to improve their programming. However, if professionals did not have time or were not able to access these additional resources, the activities, themselves, were designed to be immediately usable. All of the supplies were included, and the activities were straightforward enough so that partners could open the box, start implementing them, and potentially learn new ways to engage the public just by doing so.

Evaluation findings confirm that there were many reasons why the public and professional products, and in particular the NanoDays kits, helped raise the capacity of professionals to do nano education. This included the fact that best practices were embedded into the design of the materials, partners were encouraged to modify the materials based on their audiences' needs, and information was provided about how to engage various groups and convey a range of nano content. By purposefully creating activities to be inclusive, findings show that the Network encouraged professionals to gain a deeper understanding of new and different ways to engage the public in nano and their other programming (Evaluation #1: Goss et al., 2016).

⁷ The nano concepts and public engagement practices that the Network emphasized are listed in the Findings Sections related to Professional Goals #3 and #4.

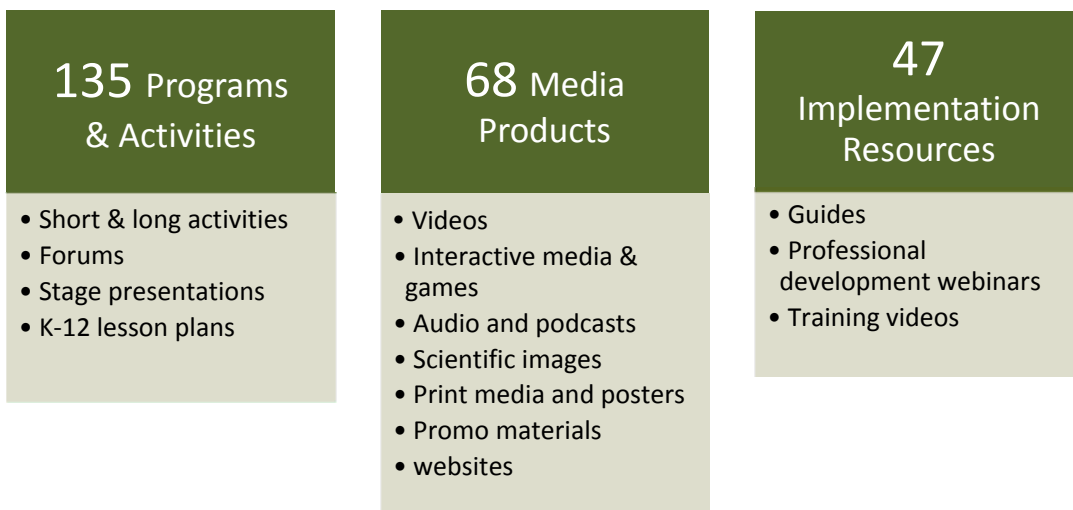


Figure 5. Over the ten years of the project, the Network provided a variety of educational products to help partners engage the public in nano.

Professional development opportunities that allowed for deeper learning

The Network's professional development opportunities were another way partners enhanced their capacity to engage the public in nano. In Years 6-10, NISE Net professional development activities included one-hour online webinars as well as multi-day in person Network-Wide and regional meetings (see Figure 6). By preparing for and having the opportunity to present their own work, Network partners increased their own capacity to conduct nano programming and were able to share their ideas and learnings with other professionals.

In particular, the Network offered a variety of targeted workshops, online resources, and videos about several of the public engagement practices that were encouraged by NISE Net. These specific professional development offerings emphasized applying universal design, engaging Spanish-speaking audiences, and incorporating nano and society content into public programs. In Years 8 and 9, there was also an opportunity to participate in a cohort experience that allowed partners to learn more about how to carry out Team-Based Inquiry as a way to incorporate evaluation into their work. These in-depth professional development opportunities allowed professionals to deepen their understanding of how to implement a variety of practices into a range of nano and non-nano work. These experiences allowed professionals to learn from each other and see the practices in action through NISE Net's work. Evaluation findings indicate that the Network's various professional development offerings, especially in-person meetings, led professionals to not only feel more connected

with the NISE Net community but also enhanced their ability to deliver nano content with a diverse public (Evaluation #1: Goss et al., 2016).

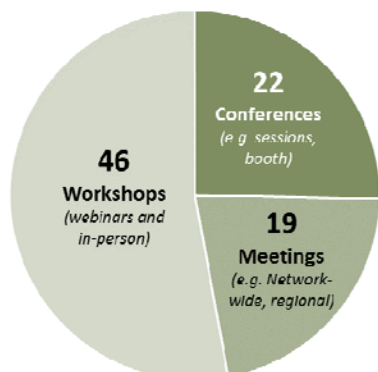


Figure 6. In Years 6-10, there were 87 professional development events offered to partners.

Nano and Society: An example of how the Network's products and professional development opportunities evolved

NISE Net provided a multitude of educational products that made it easy for partners to add nano into their programming. The Network also offered partners opportunities to learn how others were doing this work and to hear about best practices for engaging the public. Together, these Network resources allowed professionals to increase their capacity to engage the public in learning about nano in informal settings. NISE Net's Nano and Society efforts provide insight into how the Network created and refined an integrated set of educational products and professional development resources to increase the capacity of partners to cover unfamiliar topics and utilize new skills and approaches.

In the first years of the project, NISE Net created several dialogue-based forum programs to engage the public in the societal and ethical implications of nanotechnologies. These were geared toward adult audiences and covered various public policy issues related to the social dimensions of nano such as medicine, privacy, and energy. Through evaluation, the Network learned that professionals were not using these forum materials to the same degree as other products created by the Network. While professionals were interested in learning more about the societal and ethical implications of nano, they were not enthusiastic about holding forum events, in part because of this type of programming requires substantial resources (Reich et al., 2011). Network Leadership listened to this feedback and stopped producing new forum programs.

The Network talked to professional partners to learn more about the barriers and opportunities to incorporating programming that focused on the societal and ethical implications of nano. As a result, Network Leadership recognized that a very different approach was needed in order for this content to be widely integrated into partners' programming. First, nano and society themes needed to be offered through formats that partner organizations were already commonly using for family audiences, such as hands-on activities. Second, an open-ended, conversational approach focusing on publics' values was more appropriate for these audiences than a comprehensive discussion of risks and benefits of new technologies. And third, Network partners needed professional development in order to gain skills and confidence in presenting these new educational products. To help with this new approach, the Network sought out new expertise and collaborated with partners from the Center for Nanotechnology in Society at Arizona State University and with staff at the Museum of Science and Industry in Chicago.

Ultimately, the Network held a series of multi-day, in-person professional development workshops related to Nano and Society and produced a suite of associated resources. Around 100 professionals from 50 different organizations were invited to learn three "big ideas" related to technology and society, develop relevant facilitation skills and training strategies, and practice new hands-on activities (some standalone and some related to the *Nano* exhibition). Participants were also provided with physical kits they could use to do a similar training with their own staff and volunteers and implement the activities at their home organization. After the workshops, all these materials were available for anyone to download online, and Nano and Society trainings were offered online and in other Network meetings. Nano and Society activities were also incorporated into the annual NanoDays kits.

Evaluation findings indicate that by the end of the Network funding, professionals, especially those in Tier 2 and ISE organizations, had increased their confidence in and efforts around this type of work (Evaluation #1: Goss et al., 2016). By shifting from a format that was difficult for ISE staff to implement (forums) to a more familiar format (NanoDays activities), and providing deeper professional development to some professionals, the Network was able to have a greater and broader impact on professionals' practices. This case emphasizes how the right kind of products and professional development opportunities, when introducing unfamiliar practices, can play an important role in increasing professionals' ability to engage the public in learning about challenging content.



What aspects of NISE Net contributed to professionals engaging the public in nano programming?

Opportunities such as NanoDays and mini-grants that supported public engagement activities

As seen in the findings section, there is ample evaluation evidence that professionals became more confident in their ability to engage audiences in learning about nano and that they were more likely to be doing so after joining the Network (Evaluation #1: Goss et al., 2016). Although this often looked different depending on the type of organization or audience being targeted, there is no doubt that opportunities offered by NISE Net allowed professionals to accomplish this step of the logic model. In particular, NanoDays events and mini-grants were key resources that enabled a wide range of professionals to implement nano with their audiences (see Figure 7).

NanoDays, which was started in Year 3, soon became the Network's flagship event. NanoDays events occurred every spring and provided a common activity for partners across the US to be able to engage their audiences in nano. Each year, partners applied to receive the latest kit of NanoDays materials and in exchange, they were expected to offer an event that utilized the kit materials during a specific timeframe and report on their event(s). Both physical and digital downloadable kits were produced and distributed on a scale that allowed hundreds of partners to participate in the nationwide event. In the last year (2015), 250 kits were distributed; a total of 1,150 kits were distributed during Years 6-10 to 365 different organizations. Even if an organization did not receive the physical kit, partners could download all of the activities from the NISE Net website and assemble their own materials. NanoDays provided a diverse range of organizations with the occasion and materials necessary to offer nano to their audiences and to establish local collaborations among museums, scientists, and other organizations. Evaluation findings indicate that partner organizations typically used these materials well beyond NanoDays events, and that NanoDays events were often a catalyst for further involvement in the Network or partnering with others (Evaluation #1: Goss et al., 2016).

The Network's competitive mini-grants program also facilitated partners' efforts to engage the public in learning about nano. Mini-grants were small, one-time grants of up to \$3,000 that supported projects that fit into at least one of the following three categories: grants had to either involve new efforts to implement nano into existing programming; support new efforts to reach new or traditionally underserved audiences; and/or foster new partnerships between museums and nano researchers. A total of 193 mini-grants were awarded to partner organizations during Years 6-10. By offering this funding, the Network enabled professionals

to modify Network products, to utilize NISE Net practices to reach new audiences, to develop and strengthen partnerships, and to apply their skills for engaging diverse public audiences in nano. Evaluation findings indicate that the mini-grants allowed professionals to carry out nano programming in a variety of ways (Evaluation #1: Goss et al., 2016).



Figure 7. Key resources provided to partners in Years 6-10 that supported nano programming.

NanoDays events and mini-grants were two important resources that the Network provided to support partners' efforts to engage their audiences in learning about nano--although these were by no means the only ones. Professionals from a variety of organizations were able to use Network resources to incorporate nano programming in ways that worked for their organization and audiences. As mentioned above, it was common for partners to use their NanoDays products beyond their required NanoDays event. Of the partners who filled out a survey in the last year of the Network for the *Professional Impacts* evaluation and reported using NISE Net's public engagement products, 50-87% said they implemented various materials during and outside of NanoDays. This included 87% who used NISE Net's carts or hands-on activities, 78% who used NISE Net's video media, and 75% who used NISE Net's classroom resources both during and outside of the annual NanoDays events (Evaluation #1: Goss et al., 2016). Moreover, the last two years of NanoDays reports that were filled out by partners and incorporated into the *Public Impacts* evaluation indicate that 100% of partners used their kits throughout the year as well as at NanoDays (Evaluation #4: Svarovsky et al., 2014). Thus, even though it was not a requirement that partners use NanoDays materials year-round, many found them valuable resources and were motivated to integrate them into other areas of work.

Evaluation data also indicate that besides offering nano experiences at many different times throughout the year, partner organizations often provided their audiences with more than just one way to encounter nano during a visit. For example, visitors at museums might have had the opportunity to participate in presentations as well as visit the *Nano* exhibition (Evaluation #6: Guberman et al., 2016). Altogether the various materials, professional development, encouragement to use and adapt resources, and specific opportunities from NISE Net, such as NanoDays and mini-grants, allowed partner organizations to integrate diverse public engagement activities into their organizations in an ongoing, sustainable way.

What other conditions in the ISE field contributed to NISE Net's success?

Thus far, this discussion has emphasized how several aspects of the NISE Net's work were crucial for accomplishing the outcomes related to increased professional capacity and public engagement with nano. In particular, the Network's inclusive structure and guiding but flexible frameworks were important, along with carefully designed products and professional development opportunities that not only provided training in best practices but also provided information about nano content and various ways to engage different groups. Furthermore, the ability to modify and adapt products or take part in specific opportunities, such as NanoDays or mini-grants, allowed partners to enhance their capacity to engage the public in nano. However, external reasons also likely supported the outcomes that were seen for the Network. This section explores the conditions in the ISE field that contributed to the Network's success.

The ISE field has several active professional organizations that bring individuals together and support field-wide efforts. NISE Net benefited from established groups such as the Association of Science-Technology Centers (ASTC), the Association of Children's Museums (ACM), and the Visitor Studies Association (VSA), among others. Together, these organizations are examples of groups that host annual conferences or offer professional development opportunities to those in the ISE field. NISE Net was able to leverage these existing partnerships and structures as ways to reach out to new partners, keep in touch with existing partners, and disseminate the results of the Network more broadly. These organizations also support overarching work of the field by emphasizing specific issues with their members. For example, ACM has, for many years, encouraged topics, such as nutrition; practices, such as collective impact; and additional research connected with children's museums. This work likely helped increase children's museums readiness to participate in NISE Net as a national effort. Without these established professional associations, it would have been challenging for the Network to have the impact that it did.

Nonetheless, NISE Net's professional growth opportunities filled a gap for many by giving them access to professional development and resources that they might not otherwise have had. As mentioned above, while the ISE field has a number of professional associations that offer conferences, these meetings can be inaccessible to individuals in organizations with limited funding for professional development or to those who work on the frontlines with guests and cannot easily travel. For those in small organizations, it can be difficult to take advantage of conferences because there are few staff who can cover the daily demands and costs are often prohibitive. Even for those in larger organizations, costs can sometimes limit attendance at conferences to department heads or managers, excluding participation by frontline educators. NISE Net utilized several strategies to support professionals who had limited budgets and opportunities to network with peers. For example, NISE Net offered professionals, especially educators, the ability to connect with one another and share ideas or solutions to common challenges through free, virtual and in-person meetings. NISE Net also provided free products and guides that included useful information for practitioners.

During the same timeframe as the NISE Net activities covered in this report, several funding organizations including the National Science Foundation (NSF) and the Institute of Museum and Library Services (IMLS) were actively encouraging the development of additional mechanisms for cross-institutional sharing of resources and supporting other projects which aimed to compare work across many different institutions. These efforts, in conjunction with the work of NISE Net, led to the further maturing of the ISE field. For instance, besides NISE Net's online library of resources, separate repositories of educational products were created through efforts such as howtosmile (www.howtosmile.org) and the National Girls Collaborative Project (NGCP). Portal to the Public (PoPNet) also created resources focused on science communication for scientists and museum-scientist partnerships in a way that complemented but did not duplicate NISE Net's work. By identifying and working with a group of museum leaders, NSF formed the cooperative agreement for the Center for the Advancement of Informal Science Education (CAISE). The CAISE website (www.informalscience.org) became an essential resource for sharing evidence-based practices across the field. Many NISE Net partners used these additional resources and participated in these other projects.

Moreover, efforts funded by both NSF and IMLS, such as Building Informal Science Education (BISE), Developing, Validating, and Implementing Situated Evaluation Instruments (DEVISE), and Collaboration for Ongoing Visitor Experience Studies (COVES), were designed to compare work across multiple studies, instruments, or organizations in order to strengthen how the field approaches learning about and documenting their visitors' experiences. These projects, like NISE Net, all strove to bring together knowledge and resources from across the field to unify and support ISE professionals. Overall, while NISE Net was able to fill a need for the ISE field and bring together a variety of resources and professionals, these are a few examples of how the field as a whole was growing and finding ways to create connections among professionals and between research and practice. All of these varied efforts factored into the field-wide conditions that helped foster the outcomes seen by NISE Net.

Interpretation of evidence supporting “Strand 2: Educational Products”

In the previous section, we provided insights into how the NISE Net built a community with greater capacity to engage the public in learning about nano. In this section, we describe how NISE Net leveraged this community to deploy the products it produced. As with the description of Strand 1, this section highlights particular factors that seemed important to accomplishing the work and outcomes articulated in NISE Net's Logic Model. Many of these findings overlap with those included in Strand 1.



What aspects of NISE Net contributed to building a Network community?

Clear organizational structure, defined guiding frameworks, and an inclusive and flexible philosophy

As described on pages 42-44 the Network used three strategies to build a community that was capable of working together effectively: a clear organizational structure, defined guiding frameworks, and an inclusive and flexible philosophy. All three of these elements were also key in the development of educational products.

In project Years 6-10, NISE Network's organizational structure included workgroups that had different responsibilities, yet were united in their understanding of the Network and its goals. These cross-institutional teams worked together to create and distribute a variety of educational products. Different teams, with overlapping membership, worked on the various products, including educational programs, the NanoDays kits, and the *Nano* exhibition. They coordinated within and across groups to create public products that were varied yet cohesive, and that worked together in many combinations. The membership of the product development workgroups allowed the Network to create products that incorporated diverse expertise and benefited from many perspectives, allowing the products to work for many kinds of audiences and institutions. Additional dedicated workgroups focused on public learning and inclusive audiences, which provided guidance and support for all the product development teams.

Furthermore, Network teams were composed of individuals from different types and sizes of institutions (including science centers, children's museums, and universities) and from different areas of the country. The composition of Network teams to include staff from a range of organizations made these teams more representative of the Network overall, and more likely to consider the differences among implementation settings, than teams with a more limited range of perspectives would have been. This, in turn, appears to have supported the creation of educational products that could be used by a wide range of visitors.

In addition, many NISE Net workgroups were in regular contact with Network partners. This included the Network Community team, which was explicitly charged with coordinating partner work and communicating with professionals, but also the product development teams (e.g. the Exhibits team and the NanoDays team). There was also substantial overlap in membership between the Community workgroup and product development teams. Workgroup members communicated regularly and directly with Tier 2 institutions to plan

educational products, get feedback on draft versions, introduce new products as they were distributed, and offer related professional development opportunities.

Early in Years 6-10, the NISE Net also produced a series of guiding frameworks that supported the creation of an integrated, coherent suite of educational products. In particular, the content map identified key concepts that a range of experts—including informal educators, nanoscale scientists and engineers, and social scientists—considered most important for engaging the public in learning about nano. A complementary learning framework identified the kinds of learning (including and in addition to content knowledge) that the Network valued, and provided examples of how public audiences would engage in those types of learning (Ellenbogen et al., 2012). These frameworks were used to guide the creation of all educational products in Years 6-10, providing intellectual coherence across products. The documents also seem to have encouraged diversity in content and product types by providing a range of examples for the ways that public audiences might learn about nano in informal settings. Moreover, the frameworks offered guidance to partners who wanted to modify, combine, or customize any of the products to better suit their needs.

Finally, the inclusive and welcoming philosophy that encouraged many institutions to join the Network also encouraged Network partners to engage as many public audiences as possible in learning about nano. From early on (i.e. in Years 1-5), Network leadership recognized that educational products would be more successful—and more likely to be implemented—if professional partners were able to adapt them in order to work for their audiences, within existing programmatic efforts, and organizational priorities. Leadership encouraged the development of flexible and open-source products, as they realized that it was an important way to welcome more and varied partners into the Network and promote broader use of Network resources.

Taking risks and making choices

The Network as a community was willing to take calculated risks and learn from previous successes and failures. Over the first five years of the project, Network Leadership experimented with different product formats, listened to partners, and paid attention to evaluation results to determine what was successful and what was challenging about the products they had created. By Year 6, Leadership had a better sense of where to expend resources and what activities to continue (and not continue) in order to have the greatest impact. For example, the NanoDays kits were very popular among partners and were a high priority to continue to develop and support. In contrast, forums were not widely used, so they were not continued. The previously developed large-scale exhibition (though educationally successful) was not widely adopted by partners because of its large footprint and high cost. The Network changed course and developed the *Nano* exhibition, which had a small footprint and could be distributed free of charge.

By consulting the community of Network partners for feedback about needs, priorities, and capacity, the Network was able to invest in successful efforts and take on new efforts and bigger risks with more confidence of success than was possible in the first five years of the project. In Years 1-5, NISE Net had built the trust and capacity of partners through successful efforts such as NanoDays, intentional community building through the regional hub structure, and professional development through opportunities such as in-person meetings (Evaluation #2: Alexander et al., 2012). As a result, the first five years of work created a foundation for new initiatives and greater risks in Years 6-10.

The *Nano* exhibition and the mini-grants are two examples of the Network's calculated risk in Years 6-10. Network Leadership still wanted to create exhibits and other products that could be used without active staff facilitation, both to increase reach to more members of the public and to integrate nano education throughout more completely into partner organizations. The Network knew the earlier, large-scale exhibitions were not a viable model for widespread dissemination. Through a careful process of talking to partners, prototyping different options, and considering Network goals, the Network eventually developed new model for exhibition distribution: multiple copies of modular, small-footprint exhibitions that could be produced for a relatively low cost, distributed free of charge, and installed in many different types of organization. The *Nano* exhibition was initially produced in a run of about 50 copies—a huge number for a Network that previously had only been able to convince a handful of museums to add nano to their exhibit offerings. There turned out to be fierce demand for the smaller exhibition, and the Network was able to adjust its plans to produce more copies for a total of 93, all of which were successfully placed.

Leadership launched the mini-grant program, too, in response to needs seen across Tier 2. These mini-grants were designed to build the capacities of partners to reach the public, by developing or adjusting products for particular audiences or otherwise supplementing their work. Mini-grants were initially piloted through an invitation process, and when they proved successful, the program was expanded and the mini-grants were awarded through a competitive application process. Mini-grants were somewhat risky, because it was not clear whether these very small grants (up to \$3,000) would be enough to make a difference in what partners were able to offer on an ongoing basis. However, Network Leadership and the Community workgroup had a strong sense of partner motivation and capacity and felt the risk was likely to pay off. The reported use of mini-grant funds strongly suggests that these small grants allowed individual organizations to customize products or develop new products in ways that allowed them to reach new audiences and better integrate nano into their work in a sustainable way (Evaluation #1: Goss et al., 2016).

Children’s Museums: An example of how community growth provided new perspectives

The growth of the Network to include more children’s museums encouraged new thinking about audiences and products. While very early in the Network, many products were developed and tested with older audiences, by Years 6-10 this had changed. Partners from children’s museums and science centers with young audiences developed products that were designed to introduce age-appropriate versions of nano content for early learners, such as a story time program that paired Dr. Seuss’s *Horton Hears a Who* with a hands-on activity. These partners advocated that the content could be made appropriate and exciting for young children and the Leadership responded.

As recommended in the Year 5 evaluation summary (Reich et al, 2011), over time, the Network designed more and more of its products to reach this younger audience, reflecting visitors to both children’s and science museums. For instance, the *Nano* exhibition was designed to work for families with young children, including building activities, stools to allow access to table tops, and imaginative activities. The evaluation of this exhibition (Evaluation #3: Svarovsky et al., 2013) assessed how it worked with younger visitors more rigorously than the evaluation of the previous exhibition (Bequette, Svarovsky, & Ellenbogen, 2011). This included evaluation at a children’s museum and more attention to younger visitors at all evaluation sites.

Designing products for these audiences seems to have worked. Younger audiences did in fact use the exhibits and programs designed to include them (Evaluation #3: Svarovsky et al., 2013; Evaluation #4: Svarovsky et al., 2014), engaging in authentic and age-appropriate ways with material while their parents engaged with them as well. Evaluation findings also show that children’s museums used the specific products geared towards these audiences (Evaluation #1: Goss et al., 2016; Evaluation #6: Guberman et al., 2016). For instance, over a third of the sites that have hosted the *Nano* exhibition classify themselves as children’s museums (note that some sites classify themselves as both children’s museums and science museums).



What aspects of NISE Net contributed to creating educational products that would be used with the public?

Formats that were likely to be successfully used by many institutions

During the second five years of the project, the Network increased its capacity to create educational products that many Network partners would find feasible to implement, along with being appealing and effective for their audiences. The Network put more resources into

continuing and expanding NanoDays and also applied this increased capacity to the new *Nano* exhibition. These two products were both widely implemented by Network partners.

The development process and design of these products followed a few principles that seem to have made them particularly attractive and successful for partners. They were:

- Aligned to the key concepts and educational principles of the Network, which were familiar to partners
- Reviewed and tested with varied public audiences prior to distribution, and reviewed by scientific and educational experts, so that institutions trusted their quality and knew how their audiences were likely to respond
- Designed to be flexible and versatile so they could be used or adapted to meet local needs

The *Nano* exhibition was designed to be a compact, flexible, and compelling exhibition, with a neutral design that could fit in many settings. Approximately 400 square feet, it was installed into corners and hallways as well as more open spaces, depending on local needs. It was relatively inexpensive to produce and demand for it proved to be so high, that the Network produced 93 identical copies of the exhibition. As of 2017, some copies of the exhibition have been on display for over six years, indicating that it was durable and had enduring appeal. It was designed to be accessible to audiences of all ages and followed universal design principles. In addition, all text in the exhibition was presented equitably in English and Spanish. Evaluation studies, focused on general audiences, young audiences, visitors with disabilities, and Spanish-speaking visitors, showed success with all these groups. These results were shared with partners, and may have encouraged sites to adopt the exhibition. While initial agreements required that institutions display *Nano* for at least a year, this requirement was doubled for the second set that was distributed. This longer requirement reflected both the popularity of the exhibition (the team could set a higher standard) and the ways that the exhibition was being used by most sites (which included the fact that that previous sites had kept the exhibition on their floor for more than a year). The exhibition's key concepts align to the content map (NISE Network, 2011; see Appendix B), so it was easily complemented by NanoDays activities and other Network products.

The *NanoDays* kits were also distributed in large numbers; eight sets of kits were produced from 2008 - 2015, with up to 250 copies produced in the final years. Digital versions of the NanoDays kits were also available online, and in 2016, a book and digital compendium of all the activities and training materials was distributed to partners. In implementing NanoDays, institutions could choose to present as few or as many activities as they wanted, and evaluation findings show that partners used these during NanoDays events as required and beyond, on their own initiative (Evaluation #1: Goss et al., 2016; Evaluation #6: Guberman et al., 2016). This wide distribution and frequent use meant that the activities and other educational products in the kits were able to reach many people. NanoDays content was aligned to the content map, and specifically developed activities extended and complemented

learning that occurred in the *Nano* exhibition. NanoDays kit materials also included training resources related to content, delivery, engaging specific audiences, and other topics.

Evaluation processes that attended to needs of partners

Evaluation processes, both formal and informal, were key to product development for NISE Net and have been discussed in sections above. More detail on the role played by evaluation is worth including because the breadth of these practices are not typical of all projects. These include: the feedback processes that were built into meetings and discussions with partners; the practitioner-led assessment of products under development (including earlier prototyping processes and later Team-Based Inquiry processes); the formative and summative evaluation done by the evaluation team; and voluntary, anonymous feedback opportunities offered in conjunction with required reports.

Exhibit components, NanoDays activities, and other educational products were shared at meetings as part of NISE Net's peer review process and to encourage partners to apply for and use these resources. Surveys and discussion opportunities at these in-person gatherings provided partners with ways to explore the products and give feedback. The feedback was used to refine the products, sometimes leading to significant changes such as dropping an activity or element. For example, based on peer and audience feedback, the *Small, Smaller, Nano* table in the *Nano* exhibition was changed to improve the visitor experience and the durability of the product.

Meetings, surveys, and other opportunities for feedback were also a chance for partners to inform NISE Net Leadership about what kinds of products and content they wanted, which could in turn inform the next round of product development. These data and information gathering processes, unfacilitated by evaluators, helped to ensure that the Network was creating educational products that would be used by partners and were informed by their expertise.

Workgroups also used a structured Team-Based Inquiry (TBI) process (Pattison, Cohn, & Kollmann, 2014) in order to gather feedback from visitors at various institutions about each activity developed. TBI is a process of practitioner-led inquiry or formative evaluation which was developed and shared across the Network beginning in Year 6. It was designed to allow practitioners to get the data they needed, when they needed it, about the products to make appropriate changes. Evaluators and developers both wanted each team to have quick and usable feedback on activities and products, and they considered TBI a valuable and useful way to do it. Notably, the NanoDays development team embraced this process; they had always required feedback from visitors and professionals as part of their development and shifted easily from evaluator-led studies to TBI (Ostman, 2016). Their detailed development process also included feedback from external educators and subject matter experts along with input from NanoDays team member. The feedback the NanoDays team gathered from visitors was used to refine and improve prototype activities. By collecting these data, NISE Net could feel

confident that NanoDays activities could be implemented successfully with a range of visitors in different institutional settings.

For the development of the *Nano* exhibition, the team used a combination of evaluator-led formative evaluation and developer-led TBI at the Science Museum of Minnesota and Sciencenter (Ithaca, NY) to gather visitor feedback for improvement. This testing included participation by a variety of different audiences, including visitors with disabilities. Completing these formative activities allowed the team to make changes and modifications to help ensure the exhibition was usable in a wide range of institutions and accessible for many audiences. Summative evaluation of *Nano* by the Evaluation workgroup occurred at a set of representative sites across the Network, and with specific attention to Spanish-speaking visitors and visitors with disabilities. This information was shared widely during the process of inviting sites to apply for a copy. Sharing summative findings allowed the partner institutions, who might be interested in receiving the *Nano* exhibition, to understand the kinds of impacts that they could expect.

Products that were attentive to costs up front and over time

Throughout the design and development process, the product development teams actively discussed the costs of producing, sharing, presenting, and maintaining products. Both the exhibition and NanoDays kits were produced at a low cost per item in order to maximize the number of products that could be made, the number of partners that could receive a product, and the number of members of the public that could be engaged nationwide. Kits and exhibitions were distributed free of cost to institutions that applied for and were awarded the product. Both the NanoDays kits and *Nano* exhibition came with all the materials required for their use, including marketing files and training materials. Though there are plenty of costs that the institutions had to bear, from consumable materials to storage to staff time, the Network was attentive to these needs. For instance, the exhibition was built to be as low maintenance as possible, with minimal electricity needed, and included spare parts of some of the materials that might be lost or damaged over time, and replacements for consumable materials. NanoDays kits contained virtually everything (except water) needed for events, and the supportive training materials made it easier for sites to put on events and use a range of volunteers (not necessarily science experts, though those were encouraged) to facilitate activities. This consistent attention to resources (time and money) at all stages of development and implementation seems to have made it easier for sites to adopt materials and use them consistently and in a variety of ways.



What aspects of NISE Net contributed to creating education products that effectively engaged the public?

Products that reached multitudes of people

The focal products for Years 6-10 of this project were specifically designed to be implemented in many institutions across the United States, in order to reach many members of the public. In addition, professionals were encouraged, and chose, to use these products in ways that extended their reach. Both the evaluation of NanoDays events and of the *Nano* exhibition carefully documented product reach as well as audience engagement.

The Evaluation team estimated that each exhibition could reach between 38% and 100% of an institution's annual visitors, depending on the size of the institution, where it was located, and how visitors travel through an institution (Evaluation #3: Svarovsky et al., 2013). The approach used by Leadership to reach many members of the public, a small footprint exhibition that doesn't require facilitation, seems to have succeeded. Final product reach was over 23 million people as of 2015, and a possible additional 9-10 million people engaging with the exhibition each year for as long as museums continue to display them at 2015 levels. As of early 2017, all *Nano* exhibition copies are still in public settings.

NanoDays kits were also designed to be able to reach many people in a variety of ways (see Figure 8). The advantage of the NanoDays kits was that they can be used at events on- or off-site, they can be used by facilitators with a range of backgrounds and low levels of training, and the activities are brief so that many visitors can experience them. In the last two years of the project, all partners that received NanoDays kits reported using the kit materials in activities and programming year-round (Evaluation #5: Svarovsky et al., 2015) ; for a fuller description of how kits were used beyond events please see page 50 of this report.

NanoDays efforts 7.2 million	<i>Nano</i> exhibition 23.2 million
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Figure 8. The total public reach between years 2005 and 2015 was over 30.4 million people.

Products designed to reach a broad variety of audiences and were effective at connecting with these audiences.

As described in the Findings for Public Goal #1, evaluation showed that the *Nano* exhibition engaged adult and child audiences effectively and appropriately within different settings. In addition:

- Evaluation showed that *Nano* engaged audiences with different levels of prior familiarity with nano and interest in science, not just science attentive audiences (Evaluation #3: Svarovsky et al., 2013)
- Smaller, exploratory evaluation studies with visitors with disabilities and Spanish-speaking audiences showed that they engaged in authentic ways with *Nano* (Evaluation #3: Svarovsky et al., 2013)
- Evaluation showed that NanoDays kits engaged audiences of different ages (Evaluation #4: Svarovsky et al., 2014)

Nano and NanoDays were not just tested and shown to be effective with a variety of audiences, they were used with many audiences as well. Two studies explored how professionals used these products, and both showed that many professionals and many institutions considered nano content to be appropriate for all visitors, not just older visitors or those with a higher interest in science (Evaluation #1: Goss et al., 2016; Evaluation #6: Guberman et al., 2016). The Museum and Community Partnerships project, in Year 11 of the NISE Network, worked to extend to even more audiences, and is reported separately (Todd, King, Cardiel, Ramos-Montañez, & Kollmann, 2017).

What other conditions in the ISE field and society contributed to NISE Net's success?

Thus far, the discussion has addressed the choices made by Network Leadership, and the ways that these choices seem to have supported the findings shown in the evaluations. But the broader context in which this project happened played a role as well. Factors that seem to have been important include: existing public awareness of nano; science museums' interest in including more current science; children's museums' interest in adding more STEM to their offerings; and the museum field's access (or lack thereof) to high quality, low price products.

The initial vision for the NISE Network originated at the National Science Foundation, where leaders who advocated for greater research and advancement in the field of nanoscience and nanotechnology also expressed concerns about public reaction and possible backlash to this new technology (Roco & Bainbridge, 2001, 2005). These concerns did not come to pass: the general public remained generally unaware of the details of nanotechnology through the duration of the project. In 2016, 74% of the public reported not feeling informed about nano and 59% said it was not personally important to them (National Science Board, 2014). This relative lack of familiarity may have allowed the Network greater flexibility in its approach to presenting nano, since members of the public did not have strongly formed preconceived

notions or concerns that needed to be addressed. Products could introduce interesting topics or stories as an entry point, rather than having to immediately address visitors' existing concerns (as might have been the case with a topic like genetically modified organisms). While public audiences did not enter with strong knowledge about nano, they seem to bring a willingness to learn about new and expanding areas of science, including nano.

At the same time, many science museums also expressed interest in expanding their current science offerings (Reich et al., 2011). The efforts of the project overall, and the Nano and Society work, in particular, aligned with contemporary movements to broaden the scope of what museums cover, which may have contributed to more adoption of products by the field. Similarly, many children's museums were looking to add science or STEM content to their floors. As described above, the Network paid more and more attention to the ways that products were appropriate for younger visitors. Though these museums may not have initially thought to present a topic like nanotechnology, the Network products worked well to meet this need. This may, as described on page 56, have been due to the strong voices of children's museums within the Network community.

Finally, Network products appear to have offered great value to partner organizations. Exhibitions, especially high quality ones, are expensive. Hands-on activity materials are less expensive in terms of materials, but require significant investment of facilitator time. While there are many activity resources widely available online, in books, and as pre-made kits, they are not always as high quality as the products NISE Net offered, and some require significant additional resources from the implementation site. Feedback from partners suggested that NISE products were consistently perceived by professionals as being high quality, floor ready, and reliable because they were extensively reviewed and evaluated. Getting these materials for free upfront and with low ongoing costs was attractive to many organizations, especially those with more limited budgets.



The Network Itself is an Outcome

Thus far, the focus of this evaluation summary has been on how the Network Leadership built an infrastructure to meet its nano education goals. Toward the end of the project, it became clear to Leadership and to partners that the Network itself—with its close professional and organizational relationships, high level of trust in its products and processes, and great capacity to mobilize around a common effort—was a major outcome. Professional findings #1

and #2 provide evidence of the ways that professionals across the network valued and engaged in the network and in local collaborations with scientists and educators.

Leadership began discussions about how to continue the relationships and collaborations with Network partners, funders, and others beginning around Year 6 because they recognized how useful this structure could be to other work. Based on feedback and their own sense of the value and function of the Network, they developed new projects using the existing infrastructure and exploring new content areas, including synthetic biology, sustainability, chemistry, Earth and space science, and more. Each project has its own goals, project structure, deliverables, and ways of engaging partners, but all use the Network infrastructure in some way, including Leadership, the Community workgroup, and the Network website. New Network projects also are all based on the key supports noted in the discussion above, including a clear organizational philosophy, defined guiding frameworks, and inclusive and flexible philosophy with respect to products and audiences. The NISE Network is now known as the National Informal STEM Education Network, and is continuing to operate with multiple sources of funding for smaller projects.

This outcome—an informal science education network with goals beyond nano—was not anticipated at the start of the project. The development and management of a network of this kind was identified early on by St. John and colleagues (2009) as a major challenge, and people had not anticipated that a network dedicated to developing and sharing content of all kinds was needed in the informal STEM education community. Thanks to the structures developed by Network Leadership, NISE Net is now a strong tool for increasing professional capacity and public engagement in new content areas and new approaches to informal education and is expected to continue to support informal STEM education for years to come.

IV. Conclusion

Overall, the NISE Network met its goals in Years 6-10. The progress made was based on the Network's work in the first five years, but took it far beyond what was accomplished by Year 5.

At the end of the first five years of the project, the Network Leadership felt that they had made significant progress on the four challenges that had been identified by St John and colleagues (2009) as vital to ensure the Network's success. In Years 6-10, the Network continued to progress on each of these challenges:

- *Identifying specific content in this emerging field of nano to teach, and how to teach it:* In Years 6-10, the Network consistently and seriously used the content map and additional guidelines.
- *The design of new informal learning resources for nano education:* The Network continued to create NanoDays kits each year, and developed and distributed the *Nano* exhibition.
- *Developing institutional capacity and readiness to do nano (including leadership, knowledge, resources, and tools):* professionals at many institutions developed in their capacity to do nano in specific ways as articulated through the professional development goals.
- *Developing and managing a national supportive network with a scale and mission different than previous networks in the informal science education field:* The Network grew and developed to a point where it could take on additional projects, an outcome that was unanticipated at the beginning of the project.

While Leadership continued to work on these challenges, they reframed their focus in Years 6-10 to using increased professional capacity and new products to reach the public. Overall, 2,709 professionals and over 30 million members of the public had engaged with the project by the end of Year 10 (Evaluation #5: Svarovsky et al., 2015). The reach and scope of learning for both professional and public audiences are impressive and also unprecedented in the ISE field, as they should be for a project of this scope.

Others can learn from how NISE Leadership organized their work, and resources are available for them to do so. The hub structure, the content documents, the professional development and other key organizational strategies appear to have been essential for the success of the network and seem appropriate for others to emulate. The work of the Network has been documented through its evaluations, Team-Based Inquiry studies, and the many guides produced by the Network. Many of these are resources that describe the project's work in ways that make them easy to use by other projects.

As noted on page 63 new projects have adopted and built on aspects of NISE Net's structure, and future research and evaluation will describe whether and how they succeed. There are

also key differences in scope and in structure between what the Nanoscale Informal Science Education Network tried and what is now being attempted under the umbrella of the National Informal STEM Education Network. These differences may better inform the field about what factors are significant in terms of planning large scale efforts in ISE. This may be an area for potential future research by others interested in professional growth and organizational change in this field.

Finally, this was an unprecedented opportunity in terms of length, scale and opportunity. There appear to have been benefits to the length and scope of the project that are not possible in shorter projects and it is worth consideration from funder and project planner perspectives. The perspective of NISE Leadership on this question is important here.

Reflection by Larry Bell, Principle Investigator for the NISE Network

The NISE Net's success is due in no small part to remarkable leadership, boldness, and collaboration across disparate groups at the National Science Foundation. The scale of the funding meant that NISE Net could provide high-quality educational materials, exhibits, professional development, and networking opportunities to hundreds of organizations and thousands of individuals in the informal science education field whether they had the financial resources to acquire such things or not. They only had to have the interest and commitment to use them. The 11 ½-year span of the award meant the Network had time to change course as needed, respond to successes and failures, and learn by working together. The openness among the project's program officers to proposals that included unknowns and to-be-defined budgets made the inevitable shifts in direction far easier to enact. Members of the NISE Net Leadership Team believe the Network is a prime example of the profound, field-wide outcomes that funders can achieve when they create and support bold initiatives that go beyond the norm.

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NISE Network Year 6-10 Logic Model

Network Year 6-10 Logic Model

OVERARCHING NETWORK GOALS

1. In partnership with the research community, develop the necessary capacities and resources to achieve a widespread, sustainable impact on the ISE field.
2. Engage the development and delivery power of the network community to raise the level of public awareness, engagement, and understanding of nanoscale science, engineering, and technology.

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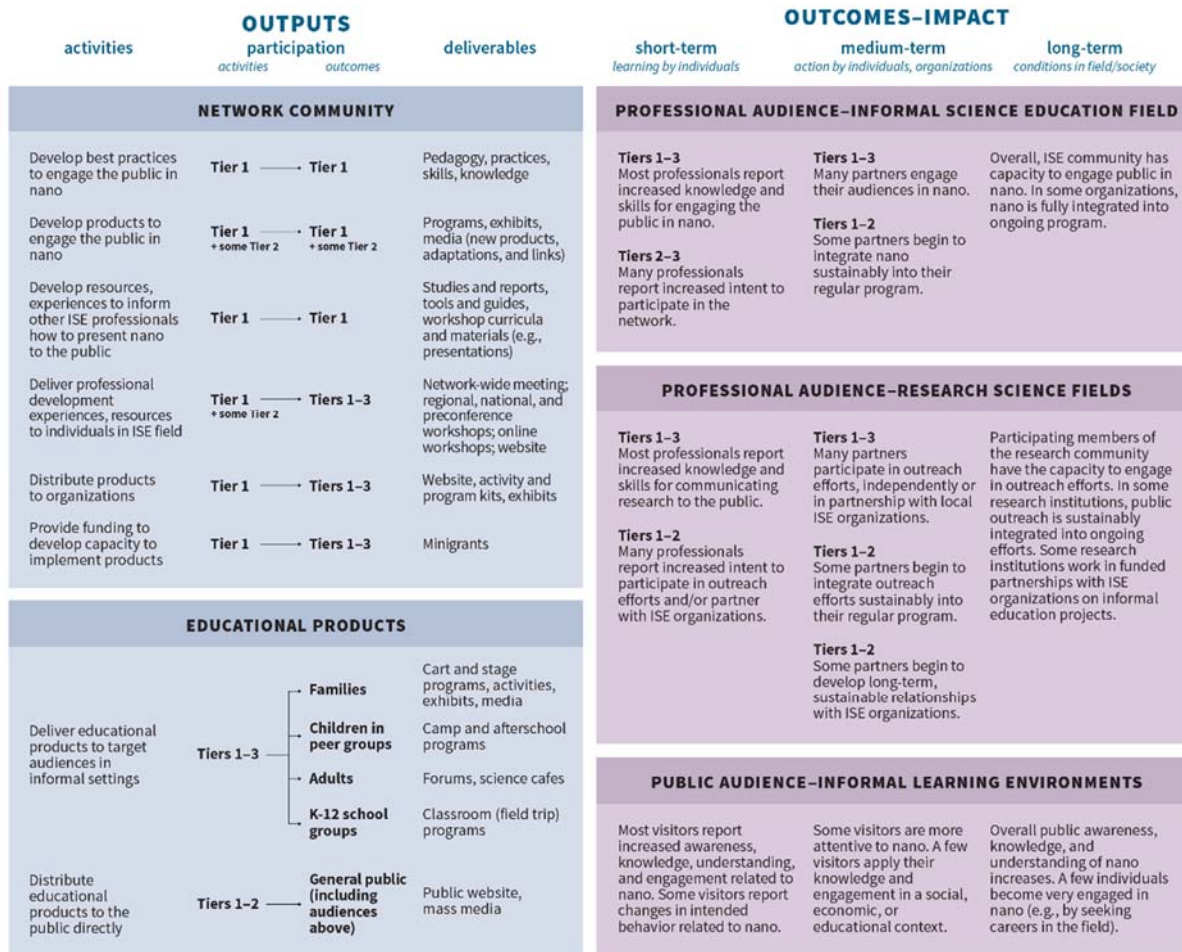
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Appendix B: Content Map

<http://www.nisenet.org/catalog/engaging-public-nano-key-concepts>

To begin to understand nano, we can explore four main concepts.

1.
**Nano is
small and different**

Nanoscale things are very small, and often behave differently than larger things do.

2.
**Nano is studying
and making
tiny things**

Scientists and engineers have formed the interdisciplinary field of nanotechnology by investigating properties and manipulating matter at the nanoscale.

3.
**Nano is
new technologies**

Nanoscale science, engineering, and technology lead to new knowledge and innovations that weren't possible before.

4.
**Nano is part of
our society
and our future**

Nanotechnologies have costs, risks, and benefits that affect our lives in ways we cannot always predict.