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NANOSCALE INFORMAL SCIENCE EDUCATION

Review of NISE Network Evaluation Findings: Years 1-5

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The key lesson the NISE Network Evaluation team has learned through the evaluation of NISE Net in Years 1-5 is that it takes a network to study a network. Generating the *Review of NISE Network Evaluation Findings: Years 1-5* was truly a collaborative effort. Multiple individuals made significant contributions to this report. The authors would like to thank the following individuals for the time and effort they took as a part of this endeavor:

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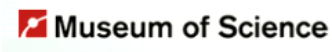

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Executive Summary

The Nanoscale Informal Science Education Network (NISE Net) is "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, 2011a). Funded by the National Science Foundation (NSF) through two consecutive grants that extend over 10 years and amount to a total of over $40 million, NISE Net is one of the largest informal science education (ISE) initiatives ever undertaken. Instituted in 2005, the Network has continuously expanded over time. By the end of Year 5, NISE Net was comprised of close to 400 science museum and university partner institutions across the United States and around the world.

Since its inception, evaluation has played a vital role in informing the work of the Network, including the development of educational products, the facilitation of professional development experiences, and the growth and expansion of the Network. In Year 5, the NISE Net Evaluation team undertook the task of coalescing findings from the 229 evaluation reports produced by NISE Net during the first five years of the Network (2005 through 2010), as well 13 other reports related to informal science learning and nano (some of which were generated by NISE Net partners outside of NISE Net). This Review summarizes what is known, based on these studies, about the reach, influence, and impact of the NISE Network. The *Review of NISE Network Evaluation Findings: Years 1-5* intends not only to inform the future direction of the Network, but also to provide the informal science education field with insight into lessons learned by NISE Net about engaging the public in informal science learning through a network of researchers and informal science educators who work together to foster public awareness, engagement, and understanding of current technologies and emerging science.

Methods

To summarize evaluation findings from the first five years of the Network, the NISE Net Evaluation team based their approach on a form of narrative review. A narrative review is a systematic way to summarize qualitative studies and grey literature by developing a narrative, relying on reflective teams of evaluators, involving stakeholders, and drawing from qualitative research methods (Jones, 2004). This narrative review...

- **developed a narrative** related to the public impacts of NISE Net and the lessons learned through the NISE Network that may be transferrable to future networks of universities and science museums;
- **relied on a reflective team of evaluators** (comprised of evaluators from the Museum of Science, Oregon Museum of Science and Industry, and Science Museum of Minnesota) who worked together to identify confirming and disconfirming evidence related to the core hypotheses and preliminary findings of the narrative;
- **involved stakeholders,** including members of the NISE Net leadership team who reflected upon the Evaluation team's initial identification of core themes and were instrumental in the final review of each chapter; and

- **drew from methods for enhancing the validity of qualitative research** to increase the trustworthiness of the findings, including triangulation, peer reviews, and member checks (Denzin, 1978; Lincoln & Guba, 1985; Maxwell, 1992).

Unlike other narrative reviews, this review also utilized multiple data sources to generate the core findings by extending beyond reviews of written evaluation reports to also include analyses from established datasets.

This Review is divided into six chapters, representing the following themes:

- Connecting ISE Professionals with Nano Informal Science Education;
- Connecting University-Affiliated Individuals with Nano Informal Science Education;
- Engaging the Public in Learning about Nano through NISE Network Educational Products;
- Engaging the Public with Societal and Ethical Implications Content through NISE Network Products;
- Making the Unfamiliar Interesting and Relevant for Museum Visitors; and
- Reaching Public Audiences through the NISE Network.

Each chapter is written to stand on its own so that the reader can make decisions about the content areas that are of interest and importance to his or her own work.

Findings

The Review yields insights on the overarching questions that were driving this investigation, including the following:

- What are the actual, possible, and potential public impacts of the NISE Network suggested by the existing evaluation studies?
- What are the implications of findings from the public impact evaluation studies for the direction of the NISE Network in Years 6-10?
- What do the findings from the NISE Network evaluation studies suggest about ways to engage visitors in learning about emerging science in an informal learning context?

What are the actual, possible, and potential public impacts of the NISE Network suggested by the existing evaluation studies?

Findings from the Review suggest that NISE Net has had and may continue to have an impact on the public's awareness, knowledge, and interest of nanotechnology. Evidence of public impact is found in the following findings:

NISE Net is reaching a large number of people across the country. Currently, 400 institutions across the nation are offering informal science education experiences about nano to their public audiences. Although the total number of people reached through the NISE Net learning experiences that take place throughout the year is currently unknown, there is evidence that these efforts collectively reach a large number of people. Counting studies conducted as a part of NanoDays demonstrated, for example, that NanoDays alone has reached close to 1 million

people. While a counting study was not conducted during the first NanoDays in 2008, studies conducted in 2009 and 2010 suggest that these two events combined reached over 840,000 visitors. Individuals reached through these efforts consisted largely of those who were participating as a family group. While NISE Net has made an effort to develop educational products that are inclusive of diverse audiences, it is unclear whether the partner institutions who implement such products are utilizing these products with an audience that is diverse.

NISE Net educational products are enhancing museum visitors' awareness, knowledge, and interest of nanoscale science, engineering, and technology (nano). Findings from formative and summative evaluations of public products created by NISE Net during Years 1-5 indicate that visitors felt more informed about nano after their participation in learning experiences with NISE Net educational products. Some visitors also developed more sophisticated definitions of nano based on their interactions with programs, exhibits, and forums. Through forums, visitors demonstrated that they learned more about the potential risks of nano, and through certain programs, visitors learned about the properties of matter at the nanoscale and about the applications of nano. Findings from the formative and summative evaluation studies also found that a large majority of the visitors feel NISE Net products are interesting and engaging.

Informal science education (ISE) and university-affiliated professionals feel NISE Net has increased their capacity to engage the public in learning about nano. University-affiliated individuals reported that their involvement in NISE Net gave them the opportunity to share their research with the public. Additionally, they feel that their participation in NISE Net increased their knowledge and ability to communicate nano content to the public and also their interest in doing so. ISE professionals were similarly impacted, as they felt that their involvement with NISE Net expanded their nano content knowledge and increased their comfort conveying that content to visitors. NISE Net participation also helped them to learn about new programming ideas, and built and strengthened professional relationships that could support their nano education efforts in the future. Although currently not measured, the reported increased capacities of both the university and ISE professionals has the potential to impact the public's awareness, knowledge, and understanding of nano.

What are the implications of findings from the public impact evaluation studies for the direction of the NISE Network in Years 6-10?

Findings from the Review point to multiple recommendations for NISE Net as it moves forward into Years 6-10. Many of these recommendations have already been acted upon by the NISE Net leadership team. Some of the key recommendations for the Network identified in the Review include the following:

There is an opportunity for NISE Net to expand its offerings and increase its impacts related to societal and ethical implications content. During Years 1-5, NISE Net set out to create a small group of products (called forums) that would engage a science-attentive adult audience in learning about societal and ethical implications (SEI). Findings from both the formative and summative evaluations demonstrated that the forums were able to engage the target audience in discussions related to the relationship between nano and society. However, these programs are not frequently offered to the public by Network partner institutions. Moving forward, it is recommended that NISE Net incorporate SEI content into a broader range of product types, including those frequently utilized by Tier 2 and 3 partners (such as hands-on NanoDays

activities) and those that reach large numbers of visitors (such as exhibits). Such efforts are already underway.

There is an opportunity for NISE Net to enhance the relevance of its educational offerings. The majority of visitors who participated in the summative evaluation of NISE Net exhibits and programs felt these learning experiences engaged them with content that was relevant to their lives. There is still, however, a substantial number of visitors (32% during the summative evaluation) who did not feel these experiences were relevant or connected to their lives. If NISE Net wishes to improve upon the relevance of NISE Net exhibits and programs for museum visitors, it may consider building upon strategies that were found to be successful at promoting relevance during the formative evaluation of exhibits and programs (such as discussing potential applications and technologies, which is a strategy that may be easier to employ as more nanotechnologies are developed over time). NISE Net may also want to explore whether some of the other aspects of the programs and exhibits that were mentioned by a smaller number of visitors also have the potential to enhance the relevance for different visitors if these strategies were employed more frequently by NISE Net professionals.

There is an opportunity for NISE Net to increase its efforts to reach underrepresented audiences. Throughout Years 1-5, NISE Net successfully reached several targeted audiences including family groups and adult-only groups. However, other audiences prioritized by the Network, including Spanish-speaking audiences and people with disabilities, have not been prioritized by Network partners implementing nano educational products at the same level. There continues to be an opportunity for NISE Net to encourage and foster practices that would enable greater participation and inclusion of underrepresented audiences. In order to meet this goal, NISE Net professional development experiences can seek to further increase partners' ability to offer nano experiences to diverse audiences. During Years 1-5, Regional Workshops, the 2009 Annual Meeting, and the DEA Workshop all addressed issues of diversity, equity, and access. However, only a minority of workshop and meeting attendees felt that goals related to engaging diverse audiences were met.

What do the findings from the NISE Network evaluation studies suggest about ways to engage visitors in learning about emerging science in an informal learning context?

In addition to generating findings that are NISE Net specific, this Review also provides insights on issues that are more broadly relevant to the informal science education field as a whole. These findings are not related to nano, but rather connect to the challenge of engaging visitors in learning about any emerging science or current technology, particularly through a network. Some key findings in this category include the following:

Interest and relevance are two distinct, yet related goals of informal science learning. There does not appear to be a relationship between how visitors rated their interest in and perceived relevance of NISE Net exhibits and programs. Visitors who rated a particular exhibit or program highly on relevance were no more likely than visitors who gave a low relevance rating to rate that same experience highly for interest. In addition, more visitors rated particular programs as interesting than relevant. This suggests that making an exhibit or program relevant is not the only way to make it interesting for visitors, a point that is important considering the fact that the potential applications and relevance of an emerging science is not always known when one

begins to introduce that topic to the public. Other aspects of an exhibit or program, such as whether it is hands-on, can make it interesting. There does appear, however, to be some overlap in the reasons specified by visitors for why they thought particular exhibits or programs were interesting and relevant. In particular, the topic of technologies and applications was mentioned by visitors both when they were describing what made an exhibit or program interesting and what made it relevant to their lives. While there does not appear to be a relationship between how visitors rate their perception of relevance and their interest level, it is possible that perceived relevance could be associated with longer term interest in the content. Unfortunately, data do not exist that would enable such an exploration at this point in time; this is an area for potential future examination.

Learning the societal and ethical implications does not diminish learning other science or technology-related content. Evaluations of NISE Net products containing societal and ethical implications (SEI) content indicate that the public learned not only about SEI but also about nanotechnology through these products. This finding was true of both the forums and other products such as the NanoDays posters, science theater, and exhibits. This indicates that it is possible to address SEI content with a public audience without sacrificing the public's opportunity to learn emerging science and technology content. However, there was some indication that SEI needs to be a primary focus of the product or the public will not report learning about this content. Therefore, if the goal is to increase public engagement in learning about SEI, it is necessary to add more than just a mention of SEI.

A dispersed network of informal learning experiences can present challenges when measuring experiences with a diverse range of goals, methods of delivery, and audiences. While studies examining the work of specific educational products provide evidence of nano learning among the participating visitors, studies that examined a broad range of NISE Net learning experiences did not draw the same conclusion. There are a variety of plausible explanations for this difference, most of which connect to the diverse range of educational experiences that are offered under the NISE Net umbrella. Learning goals and content vary depending upon the kind of NISE Net product implemented (exhibits, programs, forums, etc.), how the partners choose to implement those products (most partners modify the products as part of their implementation), and the target audiences (some partners focus on adults, others younger children, and others focus on school groups). The strength of NISE Net, and what affords it such a wide reach, is the ability for different institutions to adapt NISE Net content and products to meet their unique needs. Yet, this flexibility poses a challenge when one attempts to measure the public impact of the Network as a whole. Future studies should explore possible methods for measuring and detecting public impact of networks, which naturally operate under such diverse conditions, borrowing from other fields such as formal learning.

Review of NISE Network Evaluation Findings: Introduction

The Nanoscale Informal Science Education Network (NISE Net) is "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, 2011a). Funded by the National Science Foundation through two consecutive grants that extend over 10 years and amount to a total of over $40 million, NISE Net is one of the largest informal science education (ISE) initiatives ever undertaken. Instituted in 2005, the Network has continuously expanded. By the end of Year 5, NISE Net was comprised of close to 400 science museum and university partner institutions across the nation and around the world.

Since its inception, evaluation has played a vital role in informing the work of the Network, including the development of educational products, the facilitation of professional development experiences, and the growth and expansion of the Network. In Year 5, the NISE Net evaluation team undertook the task of coalescing findings from the 229 evaluation reports produced by NISE Net during the first five years of the Network (2005 through 2010), as well 13 other reports related to informal science learning and nano (some of which were generated by NISE Net partners outside of NISE Net). This Review summarizes what is known, based on these studies, about the reach, influence, and impact of the NISE Network. The *Review of NISE Network Evaluation Findings: Years 1-5* intends not only to inform the future direction of the Network, but also to provide the informal science education field with insight into lessons learned by NISE Net about engaging the public in informal science learning through a network of researchers and informal science educators who work together to foster public awareness, engagement, and understanding of current technologies and an emerging science.

Overview of the *Review of NISE Network Evaluation Findings*

As part of the NISE Network Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of the NISE Network since its inception in 2005 and provide an overarching summary of NISE Net Public Impacts evaluation efforts to the NISE Network and the broader ISE field. The overarching questions driving this investigation include the following:

- What are the actual, possible, and potential public impacts of the NISE Network suggested by the existing evaluation studies?
- What are the implications of findings from public impact evaluation studies for the direction of the NISE Network in Years 6-10?
- What do the findings from the NISE Network evaluation studies suggest about ways to engage visitors in learning about emerging science in an informal learning context?

This Review focuses on studies that measured the direct or indirect public impacts of NISE Net during Years 1-5. Study findings related to professional learning and Network growth that were not related to public impacts were purposefully excluded from this report as these topics were addressed in the summary document produced by Inverness Research Inc. in Year 4 of the

Network (St. John, et al., 2009b). Studies examining the perspectives of professionals were only included in this report if they related to 1) the actions professionals take (or do not take) to inform the public of nanoscale science, engineering and technology (nano), or 2) the skills or capacities professionals acquired (or did not acquire) related to engaging a public audience in learning about nano.

NISE Network background information

In 2005, the National Science Foundation (NSF) solicited proposals for a new network of informal science education (ISE) and research organizations that could work together to "foster public awareness, engagement and understanding of nanoscale science, engineering and technology" (The National Science Foundation, 2005). According to this solicitation, the goals of this network were as follows:

1. Create a sustainable service-oriented infrastructure that supports long-term efforts to educate the public about nanoscale science, engineering, and technology, as well as build capacity in the field and within participating institutions.

2. Strategically plan, develop, implement, and disseminate educational deliverables of all kinds that foster greater engagement with and understanding of nanoscale science, engineering and technology in a comprehensive way by the general public, as well as K-12 school groups.

3. Stimulate educational research and evaluation that add to the nanoscale informal science education knowledge base, inform continuous improvement of both products and processes, and guide the development of future deliverables (The National Science Foundation, 2005).

As a result of this solicitation, NSF awarded a five year, $20 million grant to three science museums later in 2005 to establish such a network: the Museum of Science, Boston, the Science Museum of Minnesota, and the Exploratorium. These institutions were commissioned to work together with 10 additional subawardee institutions. Collectively, these 13 partners engaged in a "learning-by-doing-work-together process," with the intent of producing the following deliverables:

1. Create a set of interactive media-based, and discourse-based educational products that effectively communicate and engage the public with nanoscale science, engineering and technology;
2. Generate essential new knowledge about design for learning in these subject areas; and
3. Produce a sustainable network of relationships, alliances, and professional development (NISE Network, 2005, p. 2).

These deliverables were intended to support the following public impacts:

- Desired impacts for general public audiences include 1) Increased awareness of nanoscale science, engineering, and technology and its multiple potential benefits and impacts on lives and communities; and 2) Increased understanding of the structure of matter and the forces at work on the nanoscale.

- Desired impacts for adult [science attentive] audiences include the impacts 1 and 2 for the visiting public (above), and 3) Increased understanding of societal issues including risk assessment and abatement, and of the importance of broad citizen participation in discussions about responsible research and development of new technologies (NISE Network, 2005, pp. 4-5).

The first two years of the Network featured different strands of work. These strands included the following:

- **Administration**, which focused on building up the Network's infrastructure as well as overseeing dissemination and communication activities;
- **Annual Meeting**, which designed, developed, and hosted an annual professional development experience for all Network partners;
- **Evaluation**, described further below, provided information to the Network about improving professional practice, growing and building the Network, and ways to educate the public about nanoscale content;
- **Exhibits**, which created small-scale exhibits for use in science museums of all sizes;
- **Forums**, which were aimed at engaging an adult audience in discussions of the societal and ethical issues related to nano;
- **Nanoscale Education Outreach** (NEO), which engaged graduate students, postdoctoral scholars, and education directors from Nanoscale Science, Engineering, and Technology Research Centers in learning about informal science education and science inquiry;
- **Network Media**, which sought to create media for use in museums that delivered up-to-date nano content;
- **nisenet.org**, which focused on creating a website museum professionals could use to learn more about nano education;
- **Programs**, which produced a range of nano-based programming, including stage presentations, theater, and cart demonstrations; and
- **Visualization Lab (Viz Lab)**, which was focused on generating research and innovations related to museum visitors' visualization of nano.

New strands of work were added in Year 3 or later, including the following:

- **Content Steering Group**, added in Year 5, which sought to clarify NISE Net main messages related to nano and to create a plan for educational product work in Years 6-10;
- **Diversity, Equity, and Access** (DEA), which worked to identify strategies the Network could utilize to engage a diverse public in learning about nano;
- **NanoDays**, which was focused on generating a series of local events across the nation where universities, museums, and other institutions could engage the public in learning about nano through the use of a programmatic kit;

- **Network Community**, which aimed to create a community of 100 partner institutions that would work together with a shared goal of engaging the public in learning about nano[1]; and
- **Researcher-Informal Science Education** (RISE) partnerships, which sought to create greater bridges between research centers and informal science education institutions, and later to increase the capacity of researchers to communicate scientific information to the public.

In addition to the working groups that are comprised of professionals from subawardee institutions, NISE Net also has hundreds of partner institutions across the country and around the world. These partner institutions, called the 100 Partners for most of Years 1-5, are involved in the work of the Network in various ways. As NISE Net expanded and more than 100 institutions became Network partners, the term "100 Partners" outgrew its usefulness. For Years 6-10, NISE Net has developed definitions that could be used to describe the relationship different partner institutions have with the overall Network. These definitions, which are used to distinguish different kinds of partners from one another in this report, categorize the partner institutions into three Tiers:

- Tier 1-Core Partners: These partners operate the Network, serving to develop informal educational products, create professional development opportunities, and build the capacity of other Network institutions.
- Tier 2-Nano-Infused Partners: The Network is actively working to increase the capacity of these institutions to deliver nano education experiences beyond NanoDays as an ongoing, sustainable part of their programming. These institutions are the primary target of Network resources and professional development efforts, including regional workshops, online workshops, and Network-wide meetings.
- Tier 3-Broad Reach Partners: Nano informal education is "introduced" into Tier 3 organizations for at least a limited activity like participation in NanoDays or some other type of nano educational outreach. The Network uses an open website and open-source catalog of educational materials, as well as presentations at professional conferences and other activities, to broaden the reach of nano education to these institutions. Tier 3 organizations may take materials or ideas from the Network and modify them to be used in their own activities.

NISE Network Evaluation

Evaluation played a critical role as the Network sought to produce its deliverables and achieve its desired impacts. During the first three years of NISE Net, three separate groups conducted NISE Net evaluation studies:

- Inverness Research Inc., who worked on the formative and summative evaluation of the Network development and growth, as well as professional impacts;

[1] This group was first called the 100 Partners Group and later renamed to Network Expansion. In Year 4, the name was changed to Network Community as it would better fit the current thinking of creating a community of the expanded Network.

- Multimedia Research, who worked on front-end and summative evaluations that assessed NISE Net public impacts; and
- Internal evaluators (from the Exploratorium, the Museum of Science, and the Science Museum of Minnesota), who conducted formative evaluation studies in support of the Network strands.

In Year 4, NISE Net created a more cohesive evaluation team. This team is comprised of evaluators from three internal evaluation departments (Museum of Science, Science Museum of Minnesota, and the Oregon Museum of Science and Industry) who worked together in Years 4 and 5 to conduct summative evaluation studies that examined the public impacts of NISE Net. The work of this Evaluation team was overseen by a Committee of Visitors, who reviewed all evaluation plans, methods, and findings. This Committee of Visitors includes the following individuals: Frances Lawrenz, Ph.D., Bruce Lewenstein, Ph.D., Saul Rockman, and Carol Weiss, Ph.D. This team will continue to work together in Years 6-10 to conduct studies related to the public, professional, and reach impacts of the Network.

The *Review of NISE Network Evaluation Findings* describes findings from all evaluation studies conducted during Years 1-5 of the Network. The summary of these studies aims to create a more in-depth understanding of the overall findings of NISE Net evaluation studies that can be used to both guide NISE Net in Years 6-10, as well as inform the broader ISE field about lessons learned through NISE Net that have implications for future informal science learning efforts related to current science and technology. This Review is divided into six chapters, representing the following themes:

- Connecting **ISE Professionals** with Nano Informal Science Education;
- Connecting **University-Affiliated Individuals** with Nano Informal Science Education;
- Engaging the Public in **Learning about Nano** through NISE Network Educational Products;
- Engaging the Public with **Societal and Ethical Implications** Content through NISE Network Products;
- Making the Unfamiliar **Interesting and Relevant** for Museum Visitors; and
- **Reaching Public Audiences** through the NISE Network.

These themes were derived by the NISE Network Evaluation team after examination of the Network theory of action, the original National Science Foundation grant solicitation, and conversations with the Network leadership. The Review will refer to these themes by their abbreviated titles (words found in **Bold**) in the chapters to follow. Included below is a summary paragraph describing the focus of each chapter.

Connecting ISE Professionals with Nano Informal Science Education

The *ISE Professionals* chapter provides information on the informal science education professionals who are part of NISE Net and the ways they engaged the public in learning about nano during Years 1-5 of the Network. The chapter also explores what the Network has learned about engaging educators in nano education activities as a means to reaching the public.

Connecting University-Affiliated Individuals with Nano Informal Science Education

The *University-Affiliated Individuals* chapter discusses the role university-affiliated individuals played in facilitating public learning of nanoscale science, engineering, and technology within NISE Net during Years 1-5. The chapter looks across sources of information to understand the impact on the public of university-affiliated individuals' involvement in the Network.

Engaging the Public in Learning about Nano through NISE Network Educational Products

The *Learning about Nano* chapter summarizes the evidence, as provided by NISE Net evaluation reports, regarding what the public has learned about nano content by engaging with the educational products developed by NISE Net in Years 1-5.

Engaging the Public with Societal and Ethical Implications Content through NISE Network Products

The *Societal and Ethical Implications* chapter explores the public impact of including societal and ethical implications content in NISE Net Years 1-5 products. This examines how NISE Net products that included SEI content impacted the learning, engagement, and behaviors of the public. Finally, the chapter discusses opportunities for NISE Net to expand inclusion of SEI content in its products.

Making the Unfamiliar Interesting and Relevant for Museum Visitors

The *Interesting and Relevant* chapter yields insights on the educational goals of interest and relevance based on findings from NISE Net evaluations conducted within the first five years of the Network. It looks at the meaning of both interest and relevance of nano content for museum visitors and NISE Net professionals.

Reaching Public Audiences through the NISE Network

The *Reaching Public Audiences* chapter explores NISE Net public audiences. This chapter examines the public audiences targeted through NISE Net product development and dissemination as well as the audiences that were the focus of public outreach activities implemented by NISE Net institutions. It also describes where there is existing or growing alignment between these efforts and outlines opportunities for future alignment.

Review of NISE Network Evaluation Findings: Methods

A number of existing strategies were considered for summarizing findings across NISE Network evaluation studies. These strategies included meta-analysis (Glass, McGaw, & Smith, 1981; Lipsey & Wilson, 2000), meta-synthesis (Sandelowski & Barroso, 2007) and meta-evaluation (Scriven, 1969; Stufflebeam & Shinkfield, 2007). None of these strategies, however, were deemed appropriate for summarizing findings across the kinds of evaluation studies conducted by NISE Net during Years 1-5. Only a few NISE Net evaluation studies utilized experimental or quasi-experimental designs to examine the effects of a particular intervention (e.g. Bequette, Svarovsky, & Ellenbogen, 2011; Flagg, 2008; Flagg & Knight-Williams, 2008; Kiser & Benne, 2009), which are the kinds of studies required for conducting meta-analysis or meta-evaluation. Conversely, very few studies relied purely on qualitative or ethnographic research techniques (e.g. Chin & Reich, 2007; Morgan, Del Campo, & Kollmann, 2011), which are the kinds of studies that are the focus of meta-synthesis or meta-ethnography. Evaluation reports produced by NISE Net during Years 1-5 were often mixed-methods, descriptive studies, or small-scale formative evaluation studies that were designed to inform rapid changes of exhibits and programs and other forms of short-term decision making (e.g. Grack Nelson, 2007; Miller & Cohn, 2008). Therefore, the selection of any one of these synthesizing methods would have severely limited the scope of the document and confined the findings from this investigation into limited areas, which would not be helpful for informing the future direction of the NISE Network or describing lessons learned through NISE Net with the broader field.

Given that more traditional methods for synthesizing studies such as meta-analysis and meta-synthesis were not appropriate, the NISE Net Evaluation team developed an alternative approach for summarizing the findings for this study, which was based on a narrative review. Narrative reviews are a systematic way to summarize qualitative studies and grey literature through a focus on developing a narrative, the use of reflective teams, involvement of stakeholders, and reliance on qualitative research methods (Jones, 2004). This narrative review focused on generating a narrative related to the public impacts of NISE Net and on lessons learned through the NISE Network that may be transferrable to engaging the public in learning about other current science and technology topics through a network of universities and science museums. This narrative review relied on a reflective team of evaluators (comprised of evaluators at the Museum of Science as well as those at the Oregon Museum of Science and Industry and the Science Museum of Minnesota) who worked together to identify confirming and disconfirming evidence related to the core hypotheses and preliminary findings of the narrative. This team also utilized methods for enhancing the validity of qualitative research to increase the trustworthiness of the findings (Denzin, 1978; Lincoln & Guba, 1985; Maxwell, 1992). Unlike narrative review, however, this summary utilized multiple data sources to generate the core findings, extending beyond reviews of written evaluation reports to also include analyses from established datasets.

Data Sources

Sources reviewed for the purposes of this study include evaluation studies, existing databases, and further contextualizing sources.

Evaluation studies

The core findings of the Review were generated through reviews of three categories of evaluation studies:

- Evaluations conducted by NISE Net subawardees during Years 1-5;
- Evaluations conducted by NISE Net partner institutions related to nano education during Years 1-5; and
- Evaluations conducted by institutions that are not a part of NISE Net that relate to nano-based informal science education experiences.

Evaluation studies were identified by 1) downloading reports from nisenet.org, 2) directly soliciting evaluation reports from NISE Net evaluators (past and current), 3) searching for nano-related informal science education research and evaluation studies using informalscience.org, ExhibitFiles, ERIC, and other online databases, and 4) requesting evaluation reports or suggestions for possible evaluation reports from the NISE Network partners and subawardees. In total, 242 studies were identified through this process (See Appendix B). Evaluation studies conducted outside of NISE Net were included in this report as they provided an opportunity to identify additional data that confirmed or negated findings generated through the review of NISE Net-related evaluation studies. Evaluation studies related to informal education and nano conducted before Year 1 were excluded from this report given that these studies were already captured in the literature review conducted by Multimedia Research during Year 1 (Flagg, 2005a, 2005b, 2005c).

Existing databases

In addition to evaluation studies, the core findings of the Review were also generated through analyses of datasets amassed by NISE Net during Years 1-5. These databases include the following:

- NISE Network Exhibits and Programs formative evaluation database
- NISE Network Forums formative evaluation database
- Database of NISE Network partners

NISE Network Exhibits and Programs formative evaluation database

Visitors were surveyed by members of the NISE Network Research and Evaluation team during the formative evaluation of Network exhibits and programs. Demographics were gathered and questions were asked regarding visitors' interest in the experience, enjoyment of the experience, and perceived relevance of the experience, as well as other questions which varied depending on the program. In order to examine an overview of exhibits and programs formative evaluation, results from 54 studies including 1,494 surveys were merged into one dataset. All of these studies took place at Tier 1 institutions, with the majority happening in the second and third year of the NISE Network (Table 1).[2]

Findings regarding the formative evaluation of the NISE Network exhibits and programs can be found in individual reports that are posted on www.nisenet.org and linked to the product they evaluate.

[2] Some studies were not included in the merged dataset because the questions asked were not consistent with the other studies and therefore could not be compared.

Table 1. Number of surveys from the formative evaluation of exhibits and programs by grant Year included in the merged dataset.

Grant Year	Number of Surveys	Percent of Total
Year 1 (Oct. 2005–Sep. 2006)	153	10%
Year 2 (Oct. 2006–Sep. 2007)	511	34%
Year 3 (Oct. 2007–Sep. 2008)	404	27%
Year 4 (Oct. 2008–Sep. 2009)	252	17%
Year 5 (Oct. 2009–Sep. 2010)	174	12%
Total	**1494**	

NISE Net Forums formative evaluation database

Visitors were surveyed by members of the NISE Network Research and Evaluation team during the formative evaluation of Network forums. Questions included information regarding visitors' demographics, interest in nanotechnology and the forum topic, understanding of nanotechnology and the forum topic, reasons for attending as well as other questions that varied depending on the program. In order to examine the results of the forum formative evaluation as a whole, results from 34 forums including 980 pre/post exit surveys were merged into one dataset. All of these studies took place at five Tier 1 institutions and covered five different forum topics (Table 2).

Findings regarding the formative evaluation of the NISE Network forums can be found in individual reports that are posted online at www.nisenet.org and linked to the corresponding forum.

Table 2. Number of events evaluated and number of surveys in the forum formative evaluation survey database split by forum topic.

Forum Topic[a]	Number of Events Evaluated	Number of Surveys Collected
Nanotechnology regulation	13	428
Medicine	10	317
Energy	6	97
Privacy	3	63
Consumer product labeling	2	75
Total	**34**	**980**

a.The forum topics correspond to the following forums: nanotechnology regulation to "Risks, Benefits, and Who Decides?," medicine to "Nanomedicine: Nanotechnology in Health and Healing," energy to "Energy Challenges, Nanotech Solutions?," privacy to "Privacy. Civil Liberties. Nanotechnology," and consumer product labeling to "Nanotechnology in Cambridge: What Do You Think?," and "Nanotechnology in Consumer Products." The consumer product labeling forum is not part of the NISE Net catalog of products.

Database of NISE Network partners

The online database software QuickBase is used by the NISE Network to organize and manage all information related to partner contact and involvement, as well as the professional and public nano implementation activities of Network subawardee institutions. This database is

used primarily as the mechanism for reporting to the National Science Foundation (NSF) in mid-year and annual reports. Although the database provides an extensive view of the breadth of Network partners in identifying contact information and Network involvement by person and organization, its depth into the amount of nanoeducation activities for the public or professional audiences is confined to Network subawardee institutions.

Contextual information

Examination of evaluation studies and datasets provided the majority of information for generating findings within each chapter. However, as the work spans five years, an analysis of the NISE Net catalog and annual reports was included in order to contextualize the findings.

Analysis of the NISE Network catalog
The NISE Net catalog of products provides contextual information about the topic, format, target audience, and content of the products developed by NISE Net to engage the public in learning about nano. The NISE Net Content Steering team provided the Evaluation team with a master spreadsheet listing descriptive information about each product. This spreadsheet, along with further information provided on the website, offered detailed background information on the kinds of learning experiences NISE Net currently offers the public.

NISE Network annual reports and communication with working group leaders
The Network's annual reports to NSF were analyzed in an effort to understand how the Network has documented its actions over time. Because each report has narratives from each working group, it provides an ideal glimpse into the Network's actions. For newer initiatives that have not been documented in report form as of yet, the working group leader was contacted so that this report could reflect the current thinking of the Network.

Data Analysis

Multiple strategies were employed to enhance the validity and trustworthiness of the findings:

Triangulation of findings across data sources (Denzin, 1978)

Core findings were considered to be those that appeared either across different data sources (analyses of existing databases and review of evaluation reports) or across multiple evaluation reports. In all cases, the multiple data sources and evaluations were used to identify confirming and disconfirming evidence related to a particular finding. This form of triangulation was used to reduce the impacts or biases of any one data source or evaluation report on the findings.

Peer reviews (Lincoln & Guba, 1985)

Peer reviews took place at two different levels: within the Year 5 NISE Net Evaluation team and within the NISE Net Committee of Visitors (COV). Members of the NISE Net Evaluation team from the two institutions, who were not conducting this study but had generated the initial evaluation reports (Science Museum of Minnesota and the Oregon Museum of Science and Industry), reviewed study findings during three different study phases: prior to identification of the document themes, after core findings had been annunciated, and after the first draft of this document was written. The NISE Net COV also provided feedback on the initial core findings.

Member checks (Lincoln & Guba, 1985)

Members of the NISE Net Leadership team (including members of the Network Executive Group, the Network Operating Group, and select working group leaders) were provided an opportunity to review and comment on the core findings of this study, looking specifically for findings that did not resonate with their everyday experiences of the workings of NISE Net.

Summary process

Review findings were generated through a multi-phase process. The first phase identified the core themes of the report. The second phase generated findings within each theme. Both phases utilized reflective teams as an integral part of the process.

To identify the core themes of the report, the leads of the three evaluation departments (Christine Reich at the Museum of Science; Kirsten Ellenbogen, Ph.D. at the Science Museum of Minnesota[3]; and Marcie Benne, Ph.D. at the Oregon Museum of Science and Industry) reviewed the NISE Net theory of action and the original NSF grant solicitation, and also engaged in conversations with the NISE Net Leadership team to determine areas of investigation that would be pertinent to the Network's current and future goals and the goals that were the impetus for the initial grant. From these sources, an initial list of themes was identified. This list then served as a framework the Evaluation team used to guide their review of all NISE Net evaluation studies from Years 1-5. Representatives from the three evaluation departments were assigned a subsection of the reports, and this group met to discuss alignment between the data in the reports and the initially identified themes. These discussions led to the development of an interim theme list, which was further refined by the NISE Net Leadership team. Each theme was then slightly modified during the summary process. Eventually, these themes became the separate chapters that appear in this report.

Findings were generated within each chapter or theme using the following process:

- A team of three Museum of Science evaluators assigned each evaluation study a series of primary and secondary themes based on their reading of the evaluation studies. Given the diverse range of topics covered in each evaluation, certain studies were assigned to multiple themes and therefore appear in multiple chapters.
- One evaluator was assigned to be the primary author for each chapter, with one to three other evaluators contributing to the chapter narrative.

[3] The Science Museum of Minnesota experienced a transition in leadership during the timeframe within which this document was written. At the beginning of the study, Kirsten Ellenbogen, Ph.D. was Director of Evaluation and Research in Learning. Marjorie Bequette, Ph.D. became the Director of Evaluation and Research in Learning while the report was being written.

- The evaluator assigned to a particular theme or chapter read all of the primary and secondary reports related to the theme.
- Preference was given to findings that appeared across multiple studies, or to findings that appeared in summative or research studies versus formative evaluation studies.
- When possible, new analyses were performed on existing datasets to reveal new insights. In some cases, these analyses eliminated the need to review or include the reports that were affiliated with these datasets.

Detailed information on the specific process used to generate findings within each theme is described in the subsequent chapters of this report.

1

Connecting ISE Professionals with Nano Informal Science Education

By: Amy Grack Nelson, Jane Morgan, Christine Reich, and Juli Goss

Introduction

Informal science education (ISE) professionals play a critical role in the NISE Network's ability to impact the public. To reach a broad and diverse public in cities and towns across the United States (and around the world), NISE Net relies on ISE professionals in museums, libraries, universities and other community institutions to deliver informal educational experiences that engage the public in learning about nanoscale science, engineering, and technology (nano). As part of the NISE Network's Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of NISE Net since its inception in 2005 and provide an overarching summary to the NISE Network and the broader ISE field. The *ISE Professionals* chapter looks specifically at the informal science professionals who are connected to NISE Net, and explores what the Network has learned about engaging educators in nano education activities as a means to reaching the public.

This chapter provides information on the informal science education (ISE) professionals who are part of the Network and the ways they engaged the public in learning about nano during Years 1-5. This chapter differs from studies by Inverness Research Associates in Year 4 (St. John et al., 2009b) (amongst others) in that this chapter's emphasis is not on the building of the Network, but rather, the ways in which the growing Network of professionals engage the public in learning about nano. This chapter's focus is largely on efforts related to Tier 2 and Tier 3 partners, meaning those institutions that are Network partners, but who are not funded by NISE Net nor responsible for building the Network or creating Network products; the focus of the Inverness report (St. John et al., 2009b) was largely on the Tier 1 partners—those institutions who are funded by the NISE Net NSF grant award and are responsible for the work of the Network.

Questions addressed by this chapter include the following:

1. What strategies has NISE Net utilized to prepare and encourage informal science education professionals to engage the public in learning about nano, and what do we know about the effectiveness of these strategies?
2. What kinds of educational experiences do informal science education professionals currently offer the public, and what do these offerings tells us about how and what the public might be learning?

Findings from this chapter of the Review are intended to inform future directions of NISE Net, as well as other museum-based initiatives that seek to reach the public through a large-scale network of informal science education professionals.

Methods

For this chapter, evaluators examined evaluation reports conducted by the NISE Net or Network partner institutions that directly addressed informal science education (ISE) professionals. Included were those reports that examined what ISE professionals learned through their participation in the Network and those that provided indications of the kinds of actions ISE professionals took to engage the public in learning about nano. Additional analyses were performed on existing NISE Net databases.

Investigation of Evaluation Reports

The following evaluation reports were analyzed for the purposes of this chapter. These reports were selected from over 240 NISE Net evaluation reports, as they dealt primarily with the subject of informal science education professionals and the actions that NISE Net has undertaken to impact the public through the work of these professionals.

- Oregon Museum of Science & Industry report:
  - *2010 Delivery and Reach Study: NISE Network 2010 Summative Evaluation*
- Museum of Science report:
  - *NISE Network Diversity Workshop 2009 Post-Workshop Evaluation Report*
- Science Museum of Minnesota reports:
  - *ACM Pre-Conference Workshop Formative Evaluation;*
  - *ASTC Forum Workshop Evaluation;*
  - *NanoDays Online Workshop Formative Evaluation;*
  - *NISE Network Regional Workshops: Round One 2008;*
  - *NISE Network Regional Workshops: Second Round of Workshops;*
  - *NISE Network Annual Meeting: Attendee Survey;*
  - *Regional Workshop Post-Survey Data on nisenet.org and the catalog*
  - *Year 5 Site Visits Formative Evaluation*

Analysis of NISE Net Data

In addition to summarizing findings and looking for common conclusions across the above-listed evaluation reports, evaluators conducted analyses of several NISE Net databases or data sources including the NISE Net database of people and organizations, participant lists from professional development activities, and data related to the 2010 Site Visits that had not been included in evaluation reports.

NISE Net Database

Tier 1 partners of the NISE Network track the professional and public activities of the Network including its people and organizations through an online database software called Quickbase. This database assists the Network with reporting its activities to NSF in mid-year and annual reports and with documenting the meetings and actions of the Network. For the purposes of this chapter, the Quickbase database was used to report the individuals who have attended professional development opportunities offered by the Network.

Participant Lists

Participant lists from previous Regional Workshops, Site Visits, and topical workshops were analyzed for the purposes of this report in order to examine the level of involvement of informal science education professionals in the Network.

Site Visits 2010

In the spring and summer of 2010, members of the NISE Network Community Group visited 26 partner institutions in Tiers 2 and 3. Much of the data from the 2010 Site Visits has not been written up separately, but is used throughout several chapters of the Review. This chapter incorporates findings that relate to the professional development provided by Site Visit institutions to their staff about NISE Net and its products, as well as these institutions' implementation of nano-education experiences.

Findings & Discussion

Finding 1: NISE Network professional development opportunities have reached a wide range of institutions and individuals within those institutions.

In Years 1-5, NISE Net offered a variety of nano-related professional development opportunities. These opportunities included annual meetings, regional workshops, topic specific workshops, and site visits.[4] See Table 1 for the number of individuals and institutions reached by each of these opportunities.

- Annual Meetings: Since 2005 (Grant Year 1), a NISE Network Annual Meeting has typically been held each fall. The Meeting served as a time for Tier 1, 2, and 3 members and guests of the Network, including informal science educators, scientists, and other professionals, to gather and collaborate across Network organizations and working groups, build their capacity to deliver nano-related activities to the public, and learn about the ongoing work of the Network.

- Regional Workshops: In August and September 2008 and January 2009, the Network held regional workshops to orient Network Tier 2 partners to the work of NISE Net, provide networking opportunities, and give training around nano programming development and implementation.[5]

- Forums Workshop: The Forums working group developed and delivered a 4-hour workshop on forums at the 2008 Association of Science-Technology Centers (ASTC) annual conference. The workshop was open to Tier 1, 2, and 3 partners. The forum, "Privacy. Civil Liberties. Nanotechnology." was held the night before the workshop for workshop attendees and members of the public at The Franklin Institute.

- Diversity, Equity, and Access (DEA) Workshop: The NISE Network DEA working group held a two-day Diversity Workshop on July 2009 in Washington, D.C. This workshop brought together Tier 1, 2, and 3 professionals representing institutions and organizations that serve underrepresented audiences. The purpose of this workshop was to foster awareness of and collaboration between those organizations in attendance.

- NanoDays Online Workshop: A weeklong online workshop was broadcast through the ASTC Connect website in February 2010 and included asynchronous, threaded discussions and a live web session demonstrating three NanoDays kit activities. This workshop was geared toward Tier 1, 2, and 3 staff organizing NanoDays events and, in particular, those new to NanoDays.

[4] In addition to professional development opportunities, the Network developed professional development resources including tools, guides, conference presentations, training videos, and program guides. However, this chapter does not report on these resources.

[5] Two Regional Workshops also took place in 2007. However, these workshops served as pilots of the Regional Workshops so the evaluation data from these workshops are not included in this chapter.

- Association of Children's Museums (ACM) Workshop: A day-long pre-conference workshop was held at the ACM 2010 annual conference in St. Paul, MN. The workshop, entitled "Big Thoughts about Super-Small: Nano in Children's Museums," included presentations by both Tier 1 and Tier 2 partners featuring ways children's museums can engage their audiences in nanoscale science, technology, and engineering.

- Site Visits: The Network Community group conducted a series of regional site visits to selected Tier 2 and 3 partners between April and September of 2010. The overarching goal of the regional hub site visits (3-5 visits per hub) was to deepen relationships with a small group of museum partners in hopes of infusing nano content into their institutions' activities.

The professional development opportunities reached a wide range of institutions and individuals within those institutions. Overall, of the Tier 2 and 3 partners, 213 institutions and 360 individuals participated in NISE Net professional development opportunities.[6] As illustrated in Table 1, professional development opportunities reached varying numbers of institutions and individuals. Annual meetings had the widest reach, while the forums workshop had the smallest.

Table 1. Involvement of Tier 2 and 3 individuals and institutions in the NISE Net's professional development opportunities.

Professional Development Opportunity	Number of Institutions	Number of Individuals
Annual Meetings[a]	124	166
Regional Workshops	96	133
Forums Workshop	9	10
DEA Workshop	20	23
NanoDays Online Workshop	50	55
ACM Workshop	17	25
Site Visits	26	81

a. Annual Meetings were counted if individuals attended at least one meeting. However, they could have attended multiple meetings.

Individuals from Tiers 2 and 3 tended to participate in only one type of NISE Network professional development opportunity. Part of this could be explained by the fact that some of the professional development opportunities were invite-only (Annual Meetings, Regional Workshops, DEA Workshop, and Site Visits), some were targeted to specific types of professionals (for example museum educators or diversity and access professionals), and some (such as the ACM pre-conference workshop) were open to anyone. Of the 360 individuals who attended a NISE Network professional development opportunity, almost three-quarters participated in one opportunity (see Table 2). There were only a small percentage of individuals (8%) that participated in three or more opportunities.[7]

[6] This report only includes attendance data from Tiers 2 and 3 to focus on the NISE Network's efforts to expand the Network outside of Tier 1 institutions.

[7] It is important to note that Table 2 does not include individuals from Tier 1, since in most cases they were leading the professional development efforts. However, there were some Tier 1 educators that attended multiple workshops

Table 2. Number of professional development opportunities attended by Tier 2 and 3 individuals (n=360).

Number of Opportunities	Percent of Individuals
One	73%
Two	20%
Three	6%
Four	1%
Five	<1%

The Network's professional development reached a wide range of institution types and individuals within those institutions. As illustrated in Table 3, over half (54%) of the institutions were museums and science centers, while two-thirds of the individuals (66%) reached through professional development were from museums and science centers. The Network also reached out to a large number of colleges and universities, as well as individuals in a range of other institutions. A variety of individuals within these institutions, including educators, exhibit developers, administrators, university-affiliated professionals[8], researchers, scientists, and volunteers, engaged in the professional development opportunities.

Table 3. Institution types reached through NISE Net professional development activities.

Institution Type	Percent of Institutions (n=213)	Percent of Individuals (n=360)
Museum/Science center	54%	66%
College/University	29%	22%
Government and/or policy organization	7%	5%
K-12 school	2%	2%
Other informal education organization	2%	2%
Media	2%	1%
Industry	1%	1%
Social science organization	1%	1%
Other	2%	1%

There was strong interest among institutions to participate in additional professional development offerings. During the Regional Workshops, attendees were presented with a list of 17 potential workshop topics. At least two-thirds of attendees were "interested" or "very interested" in attending 14 of the 17 potential workshops (Grack Nelson, 2009). Professional development workshops to learn about holding NanoDays at their institutions and connecting nano to their programs garnered the highest levels of interest among attendees. At the 2009

to observe and as a result received professional development. For this reason, the number of individuals participating in three or more opportunities would be much greater if Tier 1 professionals had been included in the data.

[8] There were additional professional development opportunities that were designed specifically for university-affiliated individuals. Individuals reached by these opportunities are not included in this report and findings based on these professional development activities are discussed in the *University-Affiliated Individuals* chapter of the Review.

Annual Meeting, partners ranked their interest in four potential professional development offerings for Year 5 (Grack Nelson, Svarovsky, Van Cleave, & Miller, 2009). Helping the public visualize nano received the highest rank (34% indicated that it was their first choice), while working with out-of-school audiences such as camps and afterschool programs was ranked lowest (only 14% selected it as first choice).

Not only did NISE Net professional development activities seek to reach a wide variety of institutions within Tiers 2 and 3, they also intended to help build institutional capacity by reaching out to a variety of individuals within an institution. In fact, Regional Workshops and Site Visits specifically targeted more than one individual in an institution. As illustrated in Table 4, almost two-thirds of the institutions only had one person involved in a NISE Net professional development opportunity, while close to a quarter had two people involved. Few institutions had three or more individuals participate in professional development opportunities, with 10 being the highest number of individuals reached within an institution.

Table 4. Percent of Tier 2 and 3 institutions and their corresponding numbers of individuals involved in NISE Net professional development opportunities (n=213) (NISE Network, 2011b).

Number of Individuals	Percent of Institutions
One	64%
Two	23%
Three to four	9%
Five to six	3%
Seven to eight	<1%
Nine to ten	<1%

Institutions provided their own nano-related professional development to their staff using a variety of strategies.

Even though few individuals were reached directly by NISE Net within an institution, NISE Net-trained individuals often brought knowledge back to their institution and led staff and volunteers in nano education professional development. As illustrated in Table 5, half of the sites visited during the 2010 Site Visits said they provided one-on-one or group trainings around nano (Grack Nelson & Ostgaard, 2010a). Self-training was also a common method. In some cases, staff conducted their own information search to learn nano content and activities. In other instances, someone from the institution provided their staff and/or volunteers with NISE Net program materials and had staff train themselves. One professional highlighted the fact that sites liked resources they could just hand over to volunteers saying, "Training materials that quickly bring a random volunteer up to a level; [material] that's already been field tested."[9] Groups of staff also explored programs together by learning, practicing, and reflecting on the activities. A small percentage of institutions used the Network's online resources (program information, training videos, and member comments) as a training tool. Some sites expressed a desire for more online resources, especially training videos for individual programs. "We've started using the videos, which are really helpful because reading through the activity

[9] Quotations from the 2010 Site Visits without corresponding citations are data that have not been written up in other NISE Network evaluation reports.

descriptions, I have read through a couple times. The videos have been a tremendous help." Only four sites out of 26 had not done any training with their staff outside of training offered by NISE Net.

Table 5. Types of nano-related training that 2010 Site Visit institutions provided their staff (n=26).

Type of Training	Percent of Sites
Staff-led training	54%
Self-train	42%
Group exploration	15%
Online tools	12%
Didn't provide training	15%

Note. Some sites used more than one means to train their staff.

To assist institutions in training their own staff, NISE Net developed two Nano 101 presentations for ISE professionals. The presentations provided an overview of nanoscience, applications of nanotechnology, who works in the field, and the societal and ethical implications of nanotechnology. The presentations were part of the Regional Workshops to train participants and were used as a potential training model for their staffs. Both presentations underwent formative evaluation during the Regional Workshops to ensure educators felt they were receiving a sufficient overview to be able to talk to visitors about a variety of nano-related topics. Although formative evaluation was carried out to improve the presentations (Grack Nelson & Pizza, 2008; Pizza & Grack Nelson, 2008), the Network lacks summative evaluation data on whether institutions used these presentations to train their staff and on the effectiveness of the presentations.

In institutions across the NISE Net, a variety of individuals, both from within and outside of an institution, were involved in nano education.

Within Tier 1, 2, and 3 institutions, a range of individuals were involved in nano education. During NanoDays 2010, a median of 10 internal staff and volunteers were involved in the planning and implementation of NanoDays activities (Pattison, Benne, and LeComte-Hinley, 2010). The Delivery and Reach Study looked at the number of full-time, paid staff that dedicated at least 10% of their time annually to nano-related educational activities (Pattison et al., 2010). These individuals were considered "nano education staff" for the purpose of the study. As illustrated in Table 6, the sample included a diverse range of institutions, from museums that had no full-time, paid staff to universities with 20,000 paid employees. Of the staff at these institutions, a median of 3% of were considered nano education staff. The percentage of nano education staff within an institution ranged from no staff to all of the staff. It is important to note that the median percentage of nano education staff does not reflect the part-time staff and volunteers who also contributed to the implementation of nano educational experiences at many institutions.

Table 6. Tier 1, 2, and 3 institutions' full-time, paid staff and nano education staff.[a]

Type of Staff	Median	Min.	Max.	n
Number of full-time, paid staff	18	0	20,000	138
Number of nano education staff	1	0	120	136
Percentage of staff that were nano education staff	3%	0%	100%	129

a. Nano education staff is defined as any full-time paid staff member who devoted at least 10% of his/her time to nano-related educational activities.

Although museum staff members were at the core of nano content delivery, they frequently relied on outside individuals to assist with activities. Evaluations of the Site Visits and NanoDays brought to light the variety of individuals who assisted with nano education efforts. In some institutions, volunteers helped deliver activities that required little training or specialized knowledge, such as NanoDays activities. Because some nano programming required a more advanced level of prior knowledge, other institutions relied on science-focused college students to aid in the development and/or implementation of programs. University and industry researchers/scientists played a valuable role as content advisors for projects; as guest lecturers at forums, public programs, and professional development workshops; and as facilitators of cart demonstrations and stage presentations (see the *University-Affiliated Individuals* chapter of the Review for more information).

NISE Net professional development opportunities influenced ISE professionals' capacity to engage the public in learning about nano.

While the NISE Network had overarching goals for the work of the Network as a whole, professional development opportunities were each developed with specific goals and outcomes in mind. Looking across all evaluated professional development efforts, similarities emerged between the various efforts' goals and outcomes (see Table 7).[10] Almost all the efforts focused on increasing institutions' familiarity and engagement with the Network. Most of the professional development opportunities had a focus of increasing institutions' capacity to engage the public in nano educational experiences and their knowledge of products available in the Network's online catalog. Building relationships was an important outcome in more than half of the professional development offerings. Additional outcomes included enhancing partners' ability to offer nano educational experiences to diverse audiences, increasing partners' connections to local scientists/researchers to help with their nano education efforts, and encouraging partners to share their nano educational products and related experiences with the Network. Overall, all of the goals and outcomes were important for building a network of 100+ institutions involved in nano education efforts.

[10] All of the NISE Net professional development efforts in Table 7 went through a formative evaluation process to provide insight into the impact of the efforts and identify opportunities for improvement. Although some efforts may have included activities related to the themes in Table 7, evaluation data were only included in the discussion of each theme if the efforts had explicitly stated outcomes related to that particular theme.

Table 7. Common themes among goals and outcomes of NISE Network professional development activities.

Increase Institutions'...	2008 ASTC Forums Workshop	2008-2009 Regional Workshops	2009 DEA Workshop	2009 Annual Meeting	2010 NanoDays Workshop	2010 ACM Workshop	2010 Site Visits
Familiarity and engagement with the Network	X	X	X		X	X	X
Knowledge, skills and tools to build capacity for engaging the public in nano	X	X		X	X	X	X
Awareness of the products available in the Network's catalog	X	X			X	X	X
Relationships and partnerships with other institutions in the Network		X	X	X		X	
Ability to offer nano experiences to diverse audiences		X	X	X			
Connections with scientists/ researchers and awareness of ways to work with them		X		X			X
Interest in contributing to the Network					X		X

Formative evaluation studies were conducted on the professional development experiences listed in Table 7 (e.g. Grack Nelson, 2009; Grack Nelson & Ostgaard, 2010a; Lindgren-Streicher, 2009). These studies explored whether participants felt the programs were successful at achieving their stated outcomes. Although not conclusive, a review of the findings from these studies provided an indication of where NISE Net might have been successful at achieving its stated aims across programs and also indicated opportunities for further efforts.

Participants became familiar with NISE Net through its professional development offerings.

Professional development efforts were successful in increasing participants' familiarity with the NISE Network. At the various workshops and meetings, Tier 1 NISE Net staff provided overviews of the NISE Network, gave updates on current and future work of the Network, and connected institutions with NISE Net staff. Almost all of the Regional Workshop participants (94%) felt the workshop strengthened their relationship with Tier 1 NISE Net staff (Grack Nelson, 2009). Most of the DEA Workshop participants (89%) felt the workshop helped them become aware of NISE Net and its goals, people, and resources (Lindgren-Streicher, 2009). Half of the NanoDays Online Workshop participants (50%) agreed and another third (34%) somewhat agreed that because of the workshop they had a greater understanding of the work of the NISE Network (Grack Nelson, Ostgaard, & Miller, 2010). After the 2009 Annual Meeting, attendees felt a strong connection between their institution and the NISE Network, with three quarters (77%) agreeing that the meeting strengthened their relationships with Tier 1 NISE Network staff (Grack Nelson et al., 2009). Additionally, most 2009 Annual Meeting attendees (87%) felt the Network had something valuable to offer their institution, citing the resources and knowledge they had received from the Network.

Some of the professional development offerings had a common goal of integrating new and existing partners into the NISE Network. For the NanoDays Online Workshop, integration referred to the creation of a nisenet.org profile. Of the 55 workshop participants, close to three quarters (73%) had a nisenet.org profile (Grack Nelson et al., 2010). Of these 40 profiles, most (80%) were created before the workshop, and only 20% were new profiles created after the start of the workshop. At the ACM workshop, participants were asked how they saw their institutions being connected to the Network. Two-thirds (67%) talked about incorporating nano into their institutions' programs and/or exhibits. Participating in NanoDays, contributing to the Network, and working with others in the Network were also mentioned as ways to be connected (Grack Nelson & Ostgaard, 2010a). Although the Forums Workshop also had this common goal, the Evaluation team did not gather data from participants related to this outcome.

The Site Visits were successful in helping partners feel more closely connected to the NISE Network. This was accomplished through personal visits from a team of NISE Network staff to the individual institutions, and resulting discussions focused on the partners' needs and how they could be involved in the Network. During post-visit interviews, almost all of the visited partners (95%) talked about ways they planned to stay connected to the Network. As shown in Table 8, two fifths said they would like to contribute or share something with the Network. Some partners felt contributing was a key way for them to have a meaningful connection to the Network: "Our connection will be successful when we can feel like we're a contributing member." Partners also talked about using NISE Network resources, partnering with other institutions involved in the Network, creating their own nano-related experiences, and attending a NISE Network meeting or workshop. One partner was interested in being involved, but wasn't sure how he/she could because the Site Visit Team did not talk about specifics.

Table 8. How Site Visit recipients saw themselves being connected to or involved in the NISE Network (n=20).

Theme	Percent of Individuals
Contributing to the Network	40%
Using NISE Network resources	35%
Partnering with other institutions in the NISE Network	15%
Creating their own nano-related educational experiences	10%
Attending a NISE Network meeting and/or workshop	10%
Other	20%
Partner was not sure what future involvement would entail	5%

Note. Some partners saw themselves being connected in multiple ways.

NISE Net partners felt the professional development opportunities enhanced their capacities related to nano informal science education.

NISE Net professional development activities worked to build individuals' capacities to engage the public in nano educational experiences. Part of building capacity included increasing individuals' knowledge about nanoscale science, engineering, and technology; increasing individuals' skills related to delivering a variety of NISE Net products to the public; and helping institutions to create their own nano experiences. Regional Workshops included targeted Nano 101 presentations to provide general nano content training to all participants. Workshop participants were also exposed to a variety of NISE Net programs and gave group presentations of one of the programs to the rest of the workshop participants. At the end of the Regional Workshops, partners developed an action plan for carrying out nano programming at their institutions, specifically in relation to the NISE Network program kit they chose to receive. At the 2009 Annual Meeting, participants were able to attend a variety of nano content sessions, such as scientists presenting on their research and other current nano topics. The Meeting also had sessions focused on delivering various types of NISE Net programs and helping participants think about how to integrate nano into topics and stories they already covered. Some workshops (Forums Workshop, ACM Workshop, and the NanoDays Online Workshop) emphasized building participants' capacities to do certain types of nano programming. Finally, Site Visits focused on providing institutions with suggestions of where and how partners could integrate nano into their current programs and exhibits.

The Regional Workshops, 2009 Annual Meeting, and ACM Workshop were all highly successful in increasing participants' comfort levels with nano content. As illustrated in Tables 9 and 10, a majority of participants came to the Regional and ACM Workshops with some level of discomfort around talking to visitors about nano and answering their nano-related questions (Grack Nelson, 2009; Grack Nelson & Ostgaard, 2010a). By the end of the workshops, most of the participants felt at least "somewhat comfortable" in their ability to talk to visitors and answer their questions. Workshops were more successful at increasing participants' comfort in talking to visitors than in answering visitors' questions, with only a third of Regional Workshop participants and less than a quarter (21%) of ACM Workshop participants feeling completely "comfortable" responding to nano-related questions. Overall, a majority of the participants still left the workshops with some level of discomfort, but only 1% left the Regional Workshop feeling "uncomfortable" and no one from the ACM workshop did. After the workshop, almost all of the ACM Workshop participants (96%) said they planned to use nisenet.org to learn more about

nanoscience and technology. Although there was no pre-meeting data for the 2009 Annual Meeting, attendees self-reported their increases in knowledge, with half the attendees (52%) agreeing and a third somewhat agreeing that the meeting increased their knowledge about new applications of nano technology.

Table 9. Regional Workshop participants' comfort with nano content.

Level of Comfort	Talking to Visitors		Answering Visitors' Questions	
	Pre (n=109)	Post (n=111)	Pre (n=110)	Post (n=111)
Comfortable	23%	65%	21%	33%
Somewhat comfortable	36%	29%	26%	55%
Somewhat uncomfortable	24%	5%	31%	11%
Uncomfortable	17%	1%	22%	1%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

Table 10. ACM Workshop participants' comfort with nano content.

Level of Comfort	Talking to Visitors about Nano		Answering Visitors' Questions about Nano	
	Pre (n=19)	Post (n=46)	Pre (n=19)	Post (n=45)
Comfortable	16%	42%	11%	21%
Somewhat comfortable	26%	54%	16%	71%
Somewhat uncomfortable	21%	4%	26%	8%
Uncomfortable	37%	0%	47%	0%

Note. Reprinted from "ACM Pre-Conference Workshop: Formative Evaluation," by A. Grack Nelson & G. Ostgaard, 2010.

Part of gauging the success of capacity building efforts was evaluating institutions' levels of preparedness to lead nano educational activities after a professional development experience. All of the Forums Workshop attendees left the workshop feeling more comfortable with the idea of presenting forum programs for adults at their institutions (Grack Nelson & LaPorte, 2008). Most of the participants (7 out of 9) felt at least "somewhat prepared" to carry out a forum, with three of these individuals feeling "prepared." Over half of Regional Workshop participants (59%) left the workshop feeling "prepared" to carry out their action plan (Grack Nelson, 2009). Over two thirds (68%) of NanoDays Online Workshop participants left the workshop feeling more comfortable using NanoDays activities with their public audience and most of the participants (90%) felt at least "somewhat prepared" to lead NanoDays activities, with almost half (48%) feeling "prepared" (Grack Nelson et al., 2010).

NISE Net professional development efforts were successful at providing institutions with new programming ideas and, as a result, increased institutions' abilities to integrate nano into their educational offerings. After the ACM workshop, almost all of the participants (92%) said they acquired new ideas for leading nano activities with young audiences and most (88%) planned to use at least one of the activities they learned about at the workshop (Grack Nelson & Ostgaard, 2010a). Additionally, over half of the ACM attendees (58%) said they would be comfortable

creating a nano-related product for their institutions. Most of the Site Visit participants (80%) gained new ideas of how to incorporate nano into topics or programming at their institutions (Grack Nelson & Ostgaard, 2010b). Partners most frequently cited gaining ideas about how to incorporate nano into their institutions' floor programming (cart demonstrations, lab activities). Partners also discussed exhibits and various programming formats (community outreach, teacher programs, camps, school programs, and adult programs). The 2009 Annual Meeting was less successful with only around half of the attendees (55%) agreeing that the meeting helped to increase their institutional capacity for creating nano education experiences and they gained new ideas of how to integrate nano into the work they already do in their institutions (Grack Nelson et al., 2009).

NISE Net partners reported that they became aware of products available in the Network's catalog through NISE Net professional development offerings.

NISE Net products were shared with Tier 2 and 3 institutions in a variety of ways. During Regional Workshops, PowerPoint presentations provided a broad introduction to the products available in the catalog. Workshop participants were also introduced to three programs and received one of the program kits for participating in the workshop. Topic-specific workshops were offered around forums, the NanoDays kit, and activities for young audiences. During the 2009 Annual Meeting, participants attended sessions on specific resources and viewed exhibits. Site Visits included presentations of what is available in the catalog, looking at the catalog, and/or modeling some of the activities.

NISE Net professional development opportunities were effective in increasing institutions' awareness and interest in NISE Net products. Almost all (97%) of the Regional Workshop participants were interested in using at least one of the NISE Net products listed in Table 11. Similarly, all of the ACM Workshop participants planned to visit nisenet.org after the workshop to look for products to use at their institutions, the NanoDays Online Workshop helped increase individuals' familiarity with the NanoDays resources available on nisenet.org (81% of participants at least "somewhat agreed" that they were more familiar with these resources after the workshop), and three quarters of participants mentioned at least one resource they learned about during the Site Visit that they were interested in trying out (Grack Nelson & Ostgaard, 2010b). When looking at interest in specific NISE Net products, NanoDays materials and programs received the most interest from Regional Workshop participants, which is reflective of the products that received the most attention during the Regional Workshop activities (see Table 11). The lower interest in forums was echoed in the Forum Workshops, where less than half of the participants (4 out of 9) said they were likely to hold a forum in the future.

Table 11. Regional Workshop participants' interest in using NISE Net products.

Product	Percent of Individuals
NanoDays materials (n=108)	97%
Programs (n=107)	88%
Exhibits (n=106)	55%
Forums (n=107)	48%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

Not only was it important for institutions to be aware of the products NISE Net had to offer, they also needed to know how to acquire those products. Overall, most participants left the Regional Workshops aware of how they could acquire the main types of NISE Net products (see Table 12), with the Network being more successful in reaching this goal during the second round of Regional Workshops in 2009. This increased success was a result of the NISE Net Regional Workshop Team's response to evaluation data and subsequent changes to the workshop format to help ensure more people left confident on how they could acquire the resources. The NanoDays Online Workshop was less successful in increasing participants' awareness of how to acquire NISE Net products, with less than half of the participants (44%) "agreeing" that they were more aware of how to find resources on nisenet.org.

Table 12. Regional Workshop participants' awareness of how to acquire specific NISE Net products.

Product	Regional Workshops 2008 (n=63)	Regional Workshops 2009 (n=45)
NanoDays materials	91%	100%
Programs	90%	100%
Forums	84%	96%
Exhibits	83%	85%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

NISE Net partners reported that participation in NISE Net professional development opportunities offered networking opportunities and fostered new relationships and partnerships.

Many of the Network's professional development opportunities focused on building relationships between Tier 2 and 3 institutions with the hope that partnerships would form around regional efforts, diversity issues, and nano education for young children. Activities to help foster relationships included informal lunches, evening dinners, extended breaks, and small group work. Additionally, as part of the Regional Workshops, participants completed an action plan, which included a section to identify other museums in their region they could potentially collaborate with and ideas of how they could collaborate.

Across professional development activities, networking was frequently cited as being of high value. Almost all of the Regional Workshop participants (94%) agreed that the workshop provided valuable networking opportunities with other museum educators (Grack Nelson, 2009). Over two-thirds of the 2009 Annual Meeting participants (69%) and more than two-fifths of the DEA Workshop participants (43%) found meeting new people and networking the

most valuable aspects of their experience (Grack Nelson et al., 2009; Lindgren-Streicher, 2009). Almost all of the ACM Workshop participants (88%) said the workshop provided valuable networking opportunities and over three-quarters (79%) felt the workshop strengthened their relationship with other individuals who work with young audiences (Grack Nelson & Ostgaard (2010a).

In addition to facilitating networking, the Network was successful in building relationships and fostering partnerships. Participants left Regional Workshops feeling better connected with others in their region and three quarters of partner institutions said they hoped to collaborate with another informal science education institutions to carry out their action plans (Grack Nelson, 2009). A majority of DEA Workshop participants (84%) felt the workshop was successful at helping them make new connections with organizations and individuals in attendance (Lindgren-Streicher, 2009). Nearly three-quarters of 2009 Annual Meeting participants (74%) felt the meeting helped them strengthen connections with others in their region (Grack Nelson et al., 2009). Most of the ACM Workshop participants (88%) said they would follow up with someone they met from the workshop (Grack Nelson & Ostgaard, 2010a).

Professional development offerings did not always increase NISE Net ISE partners' ability to offer nano experiences to diverse audiences.

Regional Workshops, the 2009 Annual Meeting, and the DEA Workshop all addressed issues of diversity, equity, and access (Grack Nelson, 2009; Grack Nelson et al., 2009; Grack Nelson & Ostgaard, 2010a; Lindgren-Streicher, 2009). At both the Regional Workshops and 2009 Annual Meeting, participants shared their institutions' strategies for working with diverse audiences. Less than half of the Regional Workshop attendees (42%) agreed that they felt more prepared to engage underserved and underrepresented audiences, while less than two-fifths of 2009 Annual Meeting attendees (39%) agreed that they gained new ideas on how to engage diverse audience. One of the outcomes of the DEA Workshop was for participants to co-create, review, or implement existing NISE Net products in new contexts or ways to make them more accessible for diverse audiences. Only a quarter of participants (25%) felt the outcome was fully addressed, with close to two-thirds (63%) feeling it was moderately addressed.

NISE Net ISE partners did not always feel that the professional development offerings helped to foster connections with scientists/researchers or awareness of ways to work with them.

NISE Net professional development activities were least successful in addressing outcomes related to connecting institutions with scientists/researchers and increasing awareness of ways to work with them (Grack Nelson, 2009; Grack Nelson et al., 2009). During the Regional Workshops, NISE Net staff provided participants with advice and tips for making connections with scientists/researchers. As a result, the Regional Workshops increased some of the participants' comfort levels working with scientists and industry representatives (see Table 13). However, by the end of the workshops there were still large percentages of partners who did not feel completely comfortable working with scientists (44%) and industry representatives (58%). The 2009 Annual Meeting included presentations by nano researchers and regional discussions about the role of scientists in informal science education. Only a little more than a third (38%) of the participants left the meeting agreeing that they had a better understanding of the role scientists can play in nano informal science education and less than a third (28%) agreed that the meeting strengthened relationships between their institutions and researchers/scientists. Additionally, partners who conducted Site Visits worked to further increase partners' awareness of local scientists/researchers in over half (58%) of their visits and most partners (86%) were

exposed to new ways to work with scientists/researchers. Unfortunately, the Network lacked data to know if the partners followed up with any of the individuals suggested or if the visit did in fact increase partners' awareness of the ways they could collaborate with scientists/researchers to deliver nano education to the public.

Table 13. Regional Workshop participants' comfort levels working with scientists and industry representatives both before and after the workshop.

Level of Comfort	Working with Scientists		Working with Industry Representatives	
	Pre (n=95)	Post (n=111)	Pre (n=110)	Post (n=111)
Comfortable	46%	56%	41%	42%
Somewhat comfortable	33%	38%	33%	52%
Somewhat uncomfortable	16%	6%	18%	4%
Uncomfortable	5%	0%	8%	2%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

Participants expressed interest in contributing to the Network, but did not always follow up on proposed actions.

There was interest among partners in the ability to contribute products and resources to the NISE Network. During the Site Visits, NISE Net staff shared various ways institutions could contribute to the Network, including commenting on items in the catalog, presenting at a NISE Net meeting or workshop, or uploading items to the catalog.[11] After the Site Visits, two-fifths (40%) of partners said they saw contributing or sharing something with the Network as a way their institutions could continue to be involved in the NISE Network.

Although partners expressed interest in contributing to the Network, there was a lack of participation in commenting on products in the catalog. The NanoDays Online Workshop had the outcome that participants would comment on NanoDays activities on nisenet.org (Grack Nelson et al., 2010). Even after NanoDays (more than a month after the workshop), none of the workshop participants had posted comments.

Finding 2: NISE Net-affiliated ISE professionals used a variety of strategies to engage the public in nano learning.

Building the capacity of ISE professionals to engage the public in nano learning was an important goal of professional development efforts, as discussed in Finding 1. This section examines the actions ISE professionals took to engage the public in learning about nano, specifically looking at the format of the activities educators chose to deliver, what influenced their implementation decisions, and barriers to implementation.

[11] Although uploading to the catalog was oftentimes mentioned as a way partners could potentially contribute to the Network, the mechanism to do so was not in place by the end of Year 5.

Informal science educators (ISE) delivered nano experiences using a variety of NISE Net-developed products.

Over the years, NISE Net developed a range of products in various formats to deliver nanoscale science, engineering, and technology content to a public audience. Most of the Network's resources and activities were made available to partner institutions on the NISE Net website, www.nisenet.org. Appendix A includes a brief description of each format through which NISE Net provides nano educational experiences.

Overall usage of NISE Network products between July 2009 and June 2010 varied across Network Tiers and product types (Pattison, Benne, & LeComte-Hinely, 2011). Cart demonstrations and facilitated activities were most widely used across all three Tiers, with all of the Tier 1 institutions using these products (see Table 14). Exhibits, displays, and media were used at a majority of the Tier 1 institutions, but at less than half of the Tier 2 and 3 institutions. The rest of the product types were used by less than half of the institutions in all three Tiers. Forums were least utilized compared to the other products, with less than a tenth of the Tier 2 and 3 institutions using forums.

Table 14. Percentage of institutions in each Tier that reported delivering NISE Network-produced educational products between July 1, 2009, and June 30, 2010.

Product Type	Tier 1 (n=10)	Tier 2 (n=61)	Tier 3 (n=80)
Cart demonstrations & facilitated activities	100%	89%	73%
Exhibits, displays, and media	60%	41%	44%
Stage presentations and museum theater	40%	23%	4%
Classroom activities	30%	39%	31%
Forums	20%	7%	3%
None	0%	8%	15%

Note. Percentages total to more than 100% because some institutions delivered more than one type of NISE Network-produced product. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Institutions delivered nano experiences using activities and ideas from a variety of NISE Net sources. As illustrated in Table 15, the overwhelming preference across institutions was NISE Net's NanoDays kit, with most of the institutions turning to the kit for activity ideas (Pattison et al., 2011). This finding was echoed in the Site Visit data, where 92% of the institutions cited using the NanoDays kit as a source of activities and/or a resource for creating new activities. The *2010 Delivery and Reach Study* also found that less than half of the institutions (47%) were visiting the nisenet.org catalog to find activities or programs and half (50%) were using other NISE Net materials. The Site Visit data provided insight into what those other materials were. Other NISE Net materials included programs or ideas institutions received at a professional development workshop or meeting, a program kit they received after attending a Regional Workshop, or materials that were developed by a NISE Net Tier 1 institution independently of the Network, such as University of Wisconsin-MRSEC activities or The Museum of Science's Amazing Nano Brothers video.

Table 15. Percent of institutions delivering nano education activities or programs from specific NISE Net sources.

Activity Source	Percent of Institutions
NanoDays kit (n=148)	93%
Nisenet.org online catalog (n=101)	47%
Other NISE Network materials (n=114)	50%

Note. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

ISE professionals decided to implement certain NISE Net activities for multiple reasons.

There were numerous reasons why ISE professionals decided to implement certain NISE Net activities over others.[12] As illustrated in Table 16, the reasons were varied with no one reason cited by over a third of the survey respondents (Pattison et al., 2011). Site Visit data provided additional insight into partners' thinking around the most common reasons for using certain NISE Net activities. A third of survey respondents chose to deliver certain activities because they complemented existing institutional programming. During the Site Visits, it became clear that some institutions would only do nano-related activities if they fit within a current offering or were tied to topics on their museum floor. As a NISE Net staff member noted about one site, "[The activity] needs to connect with what is in their institution. If it doesn't connect, they can't do it." When talking about general audience characteristics (24%), professionals chose activities that they thought would work for their audiences such as young audiences, school groups, or general visitors. As one partner stated, "Trying to go for things that I thought would be intriguing enough to pull visitors to them. Whether or not I think the people implementing are going to get successful engagement off it." Finally, a quarter of survey respondents said that activities had to be easy to implement. This included activities that required little or no training, were ready to use, and could easily translate into museum floor activities. This was especially true for NanoDays kit activities, which were developed with these specific features in mind.

Table 16. Reasons institutions reported choosing to deliver some NISE Network activities and not others (n=143).

Reasons	Proportion of Respondents
Fit with existing programs	33%
General audience characteristics	24%
Ease of implementation	24%
Staff resources	22%
Appropriate for audience age	20%
Supply cost and availability	19%
Length of activity	14%
Problems delivering nano activities	13%
Engaging activities	10%

[12] This section talks about "activities" instead of products to align with the wording used in the *2010 Delivery and Reach Study* (Pattison et al., 2011).

Staff preference	10%
Space requirements	7%
Real-world connections	3%
Other	16%

Note. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

NISE Net partners modified NISE Network activities to meet their needs and purposes.

In addition to the Network-created products described above, partners used NISE Net materials to develop their own nano education resources. This aligns with the intent of the NISE Network product development groups who purposefully created activities that could be easily modified or adapted by partners. Data from the Site Visits and the *2010 Delivery and Reach Study* provided detail on how NISE Net members were using and modifying Network educational experiences to match their diverse audiences and contexts. As illustrated in Table 17, the most common modifications were blending NISE Net activities with existing programming, adapting materials for various audiences, and stringing together two or more Network activities to create a longer program (Pattison et al., 2011). These findings were supported by the Site Visit data, which found that a majority of the sites had embedded aspects of NISE Net programming into existing programs (62%) or created "string-along" programs by combining multiple NISE Net programs (58%).

Table 17. Proportion of respondents indicating their institutions had modified Network-produced activities.

Modification Type	Percent of Respondents
Incorporated into an existing program (n=141)	67%
Adapted for a different audience (n=137)	61%
Combined two or more activities into a longer program (n=133)	53%
Adapted for different staffing needs (n=133)	45%
Changed the format or activity type (n=135)	42%
Changed the educational messages (n=127)	16%

Note. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Site Visit data provided information to illustrate the kinds of modifications that occurred. Some professionals chose to adapt NISE Net activities to fit into existing floor programming. For example, one partner said she or he used the Intro to Nano video as a quick introduction with many programs. Another partner incorporated the surface area activities into various stage presentations.

Some professionals talked about adapting programs for different audiences during site visits, particularly for younger audiences. One children's museum professional adapted the teacup activity by making teacups out of modeling clay, "because you can't give the tiny teacup to little kids, but everyone loves tea cup." Another professional from a children's museum talked about simplifying NanoDays signage for his or her younger audiences and creating take home sheets for some of the kit activities.

Creating "string-along" programs was a modification that frequently came up in Site Visit data. Professionals from one institution combined activities from the NISE Network, DragonflyTV, MRSEC, the web, and their own programming to create a nano-themed day camp. At another institution, professionals utilized the NanoDays kit as a foundation for developing a large-scale problem-based learning program. The program aimed to use the NanoDays kit to train K-12 teachers throughout the country in nanotechnology programming.

NISE Net partners also used non-NISE Net materials and resources to engage the public in learning about nano.

NISE Net partners did not limit their nano-related educational offerings to what was available through the NISE Network. In addition to modifying NISE Net products, professionals from many institutions developed their own products. The *2010 Delivery and Reach Study* found that three quarters of partners (75%) developed their own programs and activities, while Site Visits found that close to half of institutions (46%) created their own products from scratch. The inconsistencies in numbers could be an artifact of the *Delivery and Reach Study* survey respondents categorizing programs they modified as ones they created. As previously noted, it is clear that many institutions were modifying NISE Net materials to work for their settings and in some cases making significant changes from the original NISE Net products. For this reason, some institutions may have viewed these modifications as the creation of new programs and categorized them as such in the survey related to the *2010 Delivery and Reach Study*. Additionally, the differences in the populations studied for the *2010 Delivery and Reach Study* and Site Visits could explain the inconsistencies in findings. Fewer universities and those less-affiliated with NISE Net were included in the Site Visits compared to the *2010 Delivery and Reach Study*, and these institutions may have been more likely to create their own programs.

A majority of partners also used products that were not developed by the NISE Network. According to the *2010 Delivery and Reach Study*, close to two thirds of institutions (64%) used non-NISE Network created materials (Pattison et. al, 2010). The Site Visit data provided insight into who created the non-NISE Network developed materials partners were using. Site Visit participants most frequently cited activities developed by researchers and/or their students (46%) and materials found online (35%). Nano-themed books also came up at two of the Site Visits.

Professionals working at ISE institutions faced a variety of barriers to hosting nano-related exhibits and programming.

Although nano educational experiences were occurring across the Network, professionals working at ISE institutions faced barriers to providing these experiences. Regional Workshop participants cited a number of barriers to offering nano educational experiences at their institution. As illustrated in Table 18, a variety of barriers were mostly or definitely true for over half the Regional Workshop participants (Grack Nelson, 2009). The most common barriers included financial constraints, lack of staff expertise in nano, nano topics not being a priority for school groups, and nano topics seeming difficult to convey to the public. Of all the potential barriers, inconsistency of nano topics with institutional mission was most frequently cited as not being a barrier.

Table 18. Regional Workshop participants' barriers to hosting nano-related exhibits and programming at their institutions.

Barrier	Definitely Not True	Mostly Not True	Mostly True	Definitely True
Budget issues and resources constraints are a barrier. (n=108)	5%	27%	43%	26%
We lack staff expertise to bring nano topics into our exhibits and/or programs. (n=108)	8%	33%	40%	19%
Nano topics are not a priority for our school audiences. (n=108)	11%	31%	46%	12%
Nano topics seem difficult to convey to the general public. (n=107)	9%	42%	38%	10%
We would not expect nano topics to be of high interest to our audiences. (n=108)	25%	62%	13%	0%
Nano topics might be seen as controversial by our audiences. (n=107)	31%	60%	8%	1%
Nano topics are not consistent with our mission. (n=108)	67%	27%	6%	1%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

Conclusion

Major Findings

Building the capacity of ISE professionals

Through its various professional development efforts, NISE Net was successful in building the capacity of ISE professionals to engage the public in nano. ISE professionals benefited from their professional development experiences in various ways:

- They increased their familiarity with the NISE Network and strengthened their relationships with Network staff.
- They expanded their nano-related content knowledge and increased their comfort conveying that content to visitors.
- They left professional development workshops feeling prepared to lead nano educational activities with the public.
- They gained new programming ideas and increased their ability to integrate nano into their educational offerings.
- They increased their awareness of the variety of educational products available to them through the NISE Network and how to acquire those resources.
- They built and strengthened relationships with each other and in some cases formed new partnerships.

Professional development efforts were less successful in two major areas: 1) increasing ISE professionals' ability to offer nano experiences to diverse audiences; and 2) helping build relationships between ISE educators and scientists/researchers. NISE Net should consider focusing future professional development materials and efforts on these two areas as they continue to be important goals of the Network during Years 6-10.

As illustrated above, the direct experience of NISE Net professional development had many benefits for ISE professionals. However, only a third of Tier 2 and Tier 3 institutions had more than one individual in their organization attend a NISE Net professional development opportunity. This means, in a majority of institutions, the knowledge shared by the Network and the personal connection with NISE Net may only sit within one person in an institution. To build an institution's capacity to deliver nano education to the public and strengthen an institution's connection with NISE Net, the Network should focus on expanding its reach within institutions during Years 6-10.

Strategies ISE professionals use to engage the public

ISE professionals used a variety of strategies to engage the public in learning about nano. These strategies included delivering NISE Net-created products, modifying NISE Net products, creating their own educational products, or using products from sources other than the NISE Network.

Certain formats and program characteristics were more likely to be used by ISE professionals than others. Of NISE Net's resources, cart demonstrations and facilitated activities were used most frequently, while forums were the least utilized. Overall, the NanoDays kit was the most common source for NISE Net-created nano educational activities. ISE professionals had various reasons for choosing particular NISE Net products, including a product's fit with existing topics or programming in the institution, the product's appeal to a general visitor audience, and the ability to easily implement a product with little to no training. These reasons might help to explain why certain NISE Net products are utilized more than others. For example, longer, more structured programs may be harder to integrate into existing offerings than the shorter NanoDays kit activities, which are more flexible. The NanoDays activities also require less training and are appealing to a wide variety of audiences.

ISE professionals modified NISE Network products in a variety of ways in order to meet their educational needs. The most common modifications were blending NISE Net activities with existing programming, adapting materials for various audiences, and stringing together two or more Network activities to create a longer program. The variety of modifications demonstrates ownership of NISE Net programs by the partners. However, in many cases modifications were extensive, meaning the Network cannot assume that public impact findings from the *Year 5 Exhibits and Programs Summative Evaluation* (Bequette, Svarovsky, & Ellenbogen, 2011) translate to these modified products. Since modified activities are such an important part of partners' nano educational efforts, the Network may want to consider developing methods for helping Tier 2 partners determine whether their modifications are achieving their public educational goals. This could be accomplished by introducing the partners to the processes employed by Tier 1 partners such as peer reviews and visitor evaluation.

Not only were ISE professionals using NISE Net-created activities, many were drawing on non-NISE Net resources. Many partners created their own activities or drew on resources from other organizations. The most commonly used outside sources were activities created by researchers and/or their students, and materials found online.

Future Directions

The findings from this chapter bring to light some potential future directions for NISE Net research and evaluation efforts in Years 6-10.

- The relationships that exist between individuals are a central component of building a network. NISE Net was successful at providing high-value networking opportunities and fostering relationships between individuals in ISE institutions. However, the Network was less successful in building relationships between ISE professionals and scientists/researchers. Additional evaluation could be carried out to understand how the Network can better foster connections between ISE professionals and scientist/researchers.

- During the Site Visits, many of the partners said they provided their own professional development to their staff around nano education. Further understanding of what these trainings entail, what type of support is needed from the Network, and how prepared people feel after these internal trainings could be a focus of Years 6-10.

- There was high interest among institutions to contribute to the Network, but opportunities either did not exist or were underutilized during Years 1-5. Future studies could be carried out to understand how partners contribute to the Network in Years 6-10

and what impact these contributions have on the overall work of the Network, the growth of the Network, and the long-term sustainability of the Network.

- ISE professionals are modifying a wide variety of NISE Net products. Future research could focus on better understanding the decisions behind modifications to these products, the extent of the modifications, and ultimately the impact the modifications have on what the public learns about nano.

2

Connecting University-Affiliated Individuals with Nano Informal Science Education

By: Elizabeth Kunz Kollmann

Introduction

As part of the NISE Network's Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of NISE Net since its inception in 2005 and provide an overarching summary to the NISE Network and the broader ISE field. The *University-Affiliated Individuals* chapter discusses the role university-affiliated individuals played in facilitating public learning of nanoscale science, engineering, and technology (nano) within NISE Net during Years 1-5.

The origins of the inclusion of scientists & engineers in the NISE Network

Since the inception of the NISE Network, scientists and engineers have been important to the Network's success. While scientists and engineers can play a valuable role in all kinds of informal science education experiences, their importance in nanoscale science, engineering, and technology (nano) related educational experiences was considered to be particularly valuable given that this is a new and emerging field within science and technology, and hence unfamiliar to many who work in the field of informal science. In its call for proposals, the National Science Foundation (NSF) said that the nanoscale informal science education network should be a "national infrastructure that links science museums and other informal science education organizations with nanoscale science and engineering research organizations" (The National Science Foundation, 2005, p. 2). When NISE Net was created, the partner science museums took this call one step further and said that the NISE Net approach should be "to connect the scientific research community with the nation's informal science education institutions for the purpose of developing expertise and resources" (St. John, et al., 2009b).

For this reason, NISE Net has worked to increase connections between informal science education (ISE) professionals and scientists/engineers and to increase the capacities of ISE professionals and scientists/engineers to work together. To achieve these goals, NISE Net has created professional development activities for both ISE professionals and scientists/engineers. Workshops were conducted to increase connections between ISE professionals and scientists/engineers and to increase ISE professionals' comfort working with scientists and engineers (Grack Nelson, 2009; Grack Nelson & Philippe, 2008). For scientists and engineers, workshops, internships, and seminars were created through projects such as NEO (Nanoscale

Education Outreach)[13] and RISE (Research Center-Informal Science Education Partnerships)[14] to increase scientists' and engineers' knowledge of informal science education pedagogy, skills in science communication, and interest and involvement in informal science education specifically with NISE Net (Ewing, 2009; Goss & Kollmann, 2009; Kollmann, 2009).

Besides promoting connections between ISE professionals and scientists/engineers through professional development opportunities, NISE Net has created roles for scientists and engineers within the NISE Net structure. One role scientists/engineers have taken on has been advising ISE professionals regarding the nano products they create and about NISE Net more generally. Scientists and engineers have also aided in the creation of NISE Net products. Finally, ISE professionals have asked some scientists and engineers to provide informal education nano learning experiences at science museums while others have decided to provide these learning opportunities at their own institutions.

About this chapter

This chapter discusses the role university-affiliated individuals played in facilitating public learning of nanoscale science, engineering, and technology within NISE Net during Years 1-5. The original purpose of this chapter was to document the impact that scientists' and engineers' participation in NISE Net had on the public. However, the focus of this chapter shifted from scientists/engineers to university-affiliate individuals for three reasons:

1) Further review and analysis of NISE Net data and evaluation findings from Years 1-5 revealed that a broad range of university-affiliated individuals have been involved in the Network during its first five years, not just scientists and engineers;
2) Some existing datasets and evaluation reports aggregated all university-affiliated individuals and it was not possible to parse out how different types of university-affiliated individuals were involved in the Network; and
3) Using the term "university-affiliated" includes almost all of the scientists/engineers who have been involved in NISE Net as very few of these individuals work for industry.

As stated above, many kinds of university-affiliated individuals have been involved in NISE Net, and in many cases, data sources and evaluation reports group all of these individuals together regardless of professional type. An analysis of the NISE Net Quickbase database people section[15] revealed that the 541 people identified as college or university partners in the database included individuals who were researchers/scientists/engineers as well as individuals who were educators/outreach coordinators/science communicators and people who fulfilled dual roles within their universities (Table 1). While Quickbase was designed to delineate between "educators" and "researchers," this practice was not consistent across NISE Net evaluation reports. For example, the *Interview Study with Scientists* written by Inverness Research Inc. included data from interviews with university professors/researchers, outreach

[13] NEO was a workshop for graduate students designed to enhance their public engagement and inquiry skills, which was carried out during Years 1 and 2 of NISE Net.
[14] RISE is a NISE Net working group whose goal is "to foster effective education outreach partnerships between science museums and research centers, focusing on nanoscale and materials science research" (NISE Network, 2010c).
[15] Quickbase is a data management tool used by NISE Net to manage information about individual and institutional members of the Network. The people section of the database contains records of all current and former individual members of NISE Net including their contact information, institutional affiliation, job description, and level of involvement in NISE Net. This information is added to the database by NISE Net partners and not the members themselves.

directors/coordinators, and graduate students (St. John, et al., 2009a). The *RISE February 2009 Science Communication Seminar* formative evaluation report drew upon survey data collected from professors and scientists as well as graduate students and post-doctoral researchers (Goss & Kollmann, 2009). Because evaluation reports and other data sources did not specifically identify the contribution of research scientists and engineers, this chapter describes more broadly the involvement of a range of university-affiliated individuals.

Table 1. Roles of nanoscience partners from the NISE Net Quickbase database. [16]

	Number of Nanoscience College/ University Partners	Percent of Nanoscience College/ University Partners	Number of Nanoscience Industry Partners	Percent of Nanoscience Industry Partners	Number of Other Nanoscience Partners	Percent of Other Nanoscience Partners
Researcher/ Scientist/ Engineer	279	52%	19	56%	4	33%
Educator/ Outreach Coordinator/ Science Communicator	113	21%	8	24%	3	25%
No Identification	83	15%	0	0%	2	17%
Both	54	10%	2	6%	2	17%
Other	12	2%	5	15%	1	8%
Total	**541**	**100%**	**34**	**100%**	**12**	**100%**

When deciding whether to focus the chapter on university-affiliated individuals or only nanoscale science and engineering researchers, concern was expressed that such a decision would lead to the exclusion of professional scientists or engineers who did not work for universities. Analyses of existing data suggest that the use of the term "university-affiliated individuals" will not exclude large numbers of individuals from consideration. The NISE Net Quickbase database organization section indicates that 233 of the organizations affiliated with the Network are identified as "nanoscience – college/university" while only 30 are identified as "nanoscience – industry organizations." Furthermore, a look at the NISE Net Quickbase database people section reveals that of the 302 nano science partners described as "scientist/researcher/engineer," 92% work for colleges or universities. Therefore, the scientist /engineer participants in the NISE Net represent mostly colleges and universities rather than industry.

[16] These people were added to the NISE Net Quickbase database before September 15, 2010.

Methods

To generate the content of this chapter, evaluators reviewed and summarized relevant findings from NISE Net Years 1 – 5 research and evaluation reports, research and evaluation reports from other projects involving university-affiliated individuals as a part of informal education nano learning experiences, and other data sources. As outlined below, 22 NISE Net reports were included in the analysis of university-affiliated individuals' involvement in the Network:

- Inverness Research Inc. reports:
  - *NISE Net Interview Study with Scientists*
  - *Overview of the NISE Network Evaluation*
  - *Regional Workshop Interviews*
- Museum of Science reports:
  - *"Energy Challenges, Nanotech Solutions?" Forum Formative Evaluation Summary Report*
  - *"Nanomedicine in Healthcare" Forum Formative Evaluation Summary Report*
  - *NISE Net Public Impacts Summative Evaluation: Study 2*
  - *"Privacy. Civil Liberties. Nanotechnology" Forum Formative Evaluation Summary Report*
  - *RISE January 2009 Public Communication Internship Formative Evaluation*
  - *RISE February 2009 Science Communication Seminar Formative Evaluation*
  - *"Risks, Benefits, and Who Decides?" Forum Formative Evaluation Summary Report*
- Oregon Museum of Science and Industry reports:
  - *2010 NanoDays*[17] *Report*
  - *2010 Delivery and Reach Study*
  - *Nanoscale Education Outreach (NEO) Evaluation*
- Science Museum of Minnesota reports:
  - *2008 NanoDays Participating Organizations Evaluation*
  - *NISE Network Regional Workshops: Round One 2008 Formative Evaluation Report*
  - *NISE Network Regional Workshops: Second Round of Workshops Formative Evaluation*

In addition, five NSF annual reports documenting professionals' involvement in the Network were also reviewed as well as the *NISE Net Public Forums Manual.*

Additionally, the evaluators ran analyses of some NISE Net databases or data sources including the following:

- NISE Net Quickbase database[18] people and organization sections,
- nisenet.org website NanoDays participants, and
- NISE Net Materials Research Society (MRS) Scientist database.[19]

[17] According to the nisenet.org website, "NanoDays is a nationwide festival of educational programs about nanoscale science and engineering and its potential impact on the future" (NISE Network, 2010b).
[18] Quickbase is a database used by NISE Net to keep track of the individual and institution members of the Network. Information kept in the database includes contact information, how the individual or institution has been involved in NISE Net, the type of institution, and the job category of the individual.

As mentioned above, evaluators also read research and evaluation reports from other projects that involved scientists, researchers, or other university-affiliated individuals as a part of informal education learning experiences. Findings from these reports were compared to findings related to university-affiliated individuals' involvement in NISE Net. Non-NISE Net reports that were reviewed as a part of this analysis included the following:

- Inverness Research Inc. report:
  - *Dragonfly TV: Investigating the Nanoworld Summative Evaluation*
- Institute for Learning Innovation reports:
  - *Portal to the Public Front-End Summary*
  - *Portal to the Public Scientist Front-End*
  - *Portal to the Public Year 1 Formative Evaluation*
  - *Public Engagement in Current Health Science at the Current Science & Technology Center, Museum of Science, Boston*

After reviewing and summarizing findings from the data sources listed above, evaluators looked across the findings to identify common themes. Evaluators considered a theme "common" if it was identified in two or more data sources. Due to the way in which data were collected and reported in Years 1-5, it was not possible to conduct statistical analyses of data relevant to the involvement of university-affiliated individuals to include in this chapter of the Review.

[19] As part of its participation in NISE Net, MRS has created and maintains a database of scientists interested in participating in the Network.

Findings & Discussion

An analysis of existing NISE Net reports and datasets illuminated four major findings relevant to university-affiliated individuals' involvement in the NISE Net informal education nano learning experiences. These themes are:

1. The ways that university-affiliated individuals have been involved in NISE Net have been widespread and diverse.
2. University-affiliated individuals have felt that their involvement in NISE Net benefits them professionally.
3. The ways that university-affiliated individuals have benefited from their involvement in NISE Net may have had positive impacts on the public.
4. There are opportunities for university-affiliated individuals to expand their informal education nano learning experiences with the public through NISE Net.

Finding 1: The ways that university-affiliated individuals have been involved in NISE Net have been widespread and diverse.

This finding was supported by two themes that were apparent across multiple datasets and reports:

- University-affiliated individuals have participated in NISE Net in many different content and professional development roles.
- University-affiliated individuals have participated in NISE Net informal education nano learning experiences with ISE institutions and on their own.

University-affiliated individuals have participated in NISE Net in many different content and professional development roles.

A review of NISE Net reports and datasets reveals that university-affiliated individuals have taken on many different roles related to informing the public about nanoscale science, engineering, and technology over the past five years. These roles have ranged from acting as advisors to leading informal education nano learning experiences to learning about science communications and/or inquiry through professional development activities. According to the RISE webpage on the nisenet.org website, one reason for involving university-affiliated individuals in these ways is that they have content knowledge about the emerging field of nano while informal science education institutions have the knowledge about how to engage the public in nano learning (NISE Network, 2010c). NISE Net acknowledges the importance of using university-affiliated individuals to provide content knowledge about nano and recognizes the value in establishing relationships with university-affiliated individuals in order to exchange resources and ideas.

In Years 1-5 NISE Net invited some university-affiliated individuals to act as advisors for the Network as a whole and others to be content advisors for specific projects. The Quickbase database indicates that as of August 2010, 18 people including 14 university-affiliated individuals were official advisors to NISE Net.[20] Additionally, the Year 1 Annual Report states that in Year 1, 75 university-affiliated individuals acted as advisors to the exhibits and programs

[20] The database does not differentiate between Years 1 – 5 and Years 6 – 10 advisors.

team and 19 university-affiliated individuals acted as advisors to the website group (NISE Network, 2006).

Other university-affiliated individuals acted as presenters at museums or science centers during forum events, lectures, stage presentations, or cart demonstrations. University-affiliated individuals also acted as presenters at their own institutions in the same capacities as when presenting at museums and science centers during NanoDays and at other times of the year. While no Network-wide records have been kept about the number of university-affiliated individuals who participated in these activities in the first five years of NISE Net, it is known that 38 university-affiliated individuals acted as speakers at 23 forums during this time period (Goss & Kollmann, 2011; Kollmann, 2011; Kollmann & Goss, 2011; Kollmann, Reich, & Lindgren-Streicher, 2009). Besides presenting nano content to the public at museums and universities, university-affiliated individuals were also asked by NISE Net to speak at ISE and science organization meetings such as Network workshops, NISE Net annual meetings, and MRS meetings (NISE Network, 2006, 2007b, 2008c, 2009b, 2010e). It is important to note, however, that in Years 1-5 the Network did not keep track of how many university-affiliated individuals participated in this way.

Other university-affiliated individuals were involved in NISE Net through the Network's professional development activities for scientists/researchers. NISE Net decided to provide professional development opportunities for university-affiliated individuals at the inception of the Network (NISE Network, 2006) to cultivate "the science communication and public engagement skills of researchers" (NISE Network, 2010c). NISE Net's professional development activities for university-affiliated individuals included both formalized events and workshops and less formal drop-in events and educational opportunities. Formalized professional development activities for university-affiliated individuals included the following:

- Nanoscale Education Outreach workshops;
- NISE Net Regional Workshops and meetings; and
- RISE communication internships and seminars (NISE Network, 2006, 2007b, 2008c, 2009b, 2010e).

Less formal professional development activities for university-affiliated individuals included working with Forum team members to craft presentations and sessions about NISE Net at science and engineering conferences covering topics such as how to form partnerships with museums and science centers (Goss & Kollmann, 2011; Kollmann, et al., 2009; NISE Network, 2008c, 2009b, 2010e). Additionally, scientists, researchers, and other university-affiliated individuals have been among the members of the public who have used the NISE Net exhibits, programs, and forums (Goss & Kollmann, 2011; Kollmann, et al., 2009).

During the first five years of NISE Net, it was estimated that over 2,000 university-affiliated individuals were the recipients of professional development activities provided by Tier 1 institutions (NISE Network, 2008c, 2009b, 2010e). Most of these individuals were involved in less formal drop-in events and educational opportunities as opposed to formalized events and workshops that required registration. For example, 87 university-affiliated individuals were participants in the two years of NEO workshops, 4 university-affiliated individuals attended the January 2009 RISE Public Communication Internship, and 33 university-affiliated individuals attended the RISE Science Communication Seminar held at the University of Massachusetts Lowell (Ewing, 2009; Goss & Kollmann, 2009; Kollmann, 2009). In contrast to these lower participation numbers, it was reported that one American Association for the Advancement of Science (AAAS) session on communicating science offered by NISE Net Tier 1 professionals

attracted approximately 100 university-affiliated individuals (NISE Network, 2008c). Additionally, the *NISE Network Public Forums Manual* reports that on average 19% of the participants at each forum are scientists/researchers studying science. These scientists included those who study nano as well as other disciplines (NISE Network, 2007a).

The ways that university-affiliated individuals have been involved in NISE Net informal education nano learning experiences in Years 1-5 are similar to the ways that university-affiliated individuals have been involved in other informal science education projects that sought to expand the involvement of scientists and other researchers in museum education. For example, a goal of the Current Science & Technology project at the Museum of Science was to create partnerships between the Museum and scientists/researchers (Storksdieck, Stein, & Dancu, 2006). The Inverness Research Inc. summative evaluation report about *DragonflyTV: Investigating the Nanoworld* reports that scientists and education outreach staff from colleges and universities acted as content advisors during the planning phases for the TV programs. Additionally, these individuals helped children conduct science experiments during tapings of the television show (Robles, Helms, & Phillips, 2009). Finally, the *Portal to the Public* project sought to teach scientists how to interact with the public and to help scientists develop public outreach activities (Schatz & Russell, 2008). These findings indicate that other projects have felt the same way about university-affiliated individuals' involvement in informal education learning experiences as NISE Net – these individuals are important advisors, partners, and speakers especially when science and technology content is about a new or emerging field.

University-affiliated individuals participated in NISE Net informal education nano learning experiences with ISE institutions and on their own.

A review of prior reports and existing databases shows that most NISE Net ISE institutions worked with university-affiliated individuals as a part of their informal education nano learning experiences. During NanoDays, most ISE institutions involved university-affiliated individuals in their nano learning activities. ISE institutions also involved university-affiliated individuals at other times of the year. Beyond working with ISE institutions, many NISE Net affiliated colleges and universities provided informal education nano learning experiences at their own sites. Many of these colleges and universities provided these experiences during NanoDays as well as other times of the year.

NISE Net evaluation reports and data sources indicate that in Years 1-5 of the Network most informal science education institutions across all three Tiers partnered with colleges and universities to provide informal education nano learning experiences. According to the *2008 NanoDays Participating Organizations Evaluation*, 23 of the 35 (66%) institutions that filled out NanoDays reports indicated that they partnered with a university (Van Cleave, Pizza, & Cohn, 2008). Results from the *2010 Delivery and Reach Study* show that over half of the institutions that filled out NanoDays reports (53%) collaborated with a university or college (Table 2) (Pattison, et al., 2011). However, NanoDays was not the only time of the year that ISE institutions worked with colleges and universities to provide nano content to the public. Site visit data collected in the summer of 2010 show that most of the Tier 2 and 3 partners (18 of 26, 69%) who participated in this study formed some kind of partnership with scientists as a part of their NISE Net informal education nano learning experiences. While most of these 18 participants involved scientists in learning activities during NanoDays (15 of 18), some also involved scientists in outreach during other times of the year. This outreach work included the following:

- Presenting table-top activities or stage presentations (7 of 18),

- Developing informal education learning experiences materials on their own or with the help of an ISE institution (6 of 18),
- Presenting at lectures or science cafes (5 of 18),
- Educating ISE staff about nanotechnology (4 of 18), and
- Participating in programs for students (camps, field trips, etc.) (2 of 18) (Grack Nelson & Ostgaard, 2010b).

Table 2. Number and percent of NanoDays participants filling out reports who partnered with colleges/universities.

	Number of NanoDays Participants Who Submitted NanoDays Reports	Number of NanoDays Report Submitters who Partnered with Colleges/Universities	Percent of NanoDays Report Submitters who Partner
2008	35	23	66%
2009[a]	--	--	--
2010	143	76	53%
Total	178	99	56%

Note. Adapted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011 and "2008 NanoDays: Participating Organizations Evaluation," by S. Van Cleave, M. Pizza, and S. Cohn, 2008.
a. The number of NanoDays report organizations that partnered with a college or university was not recorded in 2009.

In Years 1-5 of the Network, colleges and universities were involved in NISE Net public outreach not only in conjunction with science museums, but also on their own. According to the list of 2008 NanoDays participating institutions posted on www.nisenet.org, over a quarter of the 96 organizations (30%) that took part in NanoDays were colleges or universities (NISE Network, 2008a). In 2009, the number of institutions participating in NanoDays as listed on the website increased to 197, and the percentage of colleges and universities who participated also increased to 34% of the participating organizations (NISE Network, 2009a). However, in 2010 the percentage of colleges and universities participating in NanoDays decreased slightly (30% of 197 institutions) (NISE Network, 2010a) (Table 3).

Table 3. Number and percent of NanoDays participant organizations that are colleges/universities according to participant lists from nisenet.org.

	Number of NanoDays Participating Institutions	Number of NanoDays Participating Institutions that are Colleges/Universities	Percent of NanoDays Participating Institutions that are Colleges/Universities
2008[a]	96	29	30%
2009[b]	197	67	34%
2010[c]	197	60	30%
Total	490	156	32%

a. Data came from the nisenet.org website (NISE Network, 2008a). b. Data came from the nisenet.org website (NISE Network, 2009a). c. Data came from the nisenet.org website (NISE Network, 2010a).

Colleges and universities provided informal education nano learning experiences not just during NanoDays but also at other times. According to the *2010 Delivery and Reach Study*, most of the nanoscience colleges/universities[21] that completed the survey (42 of 48, 88%) participated in some kind of K-12 nano learning experience. Most commonly, the nanoscience college/university respondents (42 of 47, 89%) reported that they delivered programs to school groups at their institution. Nanoscience colleges/universities also reported that they delivered outreach programs in the classroom (32 of 46, 70%), teacher professional development activities (26 of 42, 62%), and/or curriculum or classroom activities (24 of 44, 55%) (Table 4) (Pattison, et al., 2011).

Table 4. Types of K-12 public outreach activities delivered by nanoscience colleges/universities in 2010.

	Number of Nanoscience Colleges/Universities	Percent of Nanoscience Colleges/Universities
School group programs delivered at your institution (n=47)	42	89%
Outreach programs delivered in the classroom (n=46)	32	70%
Teacher professional development (n=42)	26	62%
Curriculum or classroom activities (n=44)	24	55%

Note. Adapted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Finding 2: University-affiliated individuals felt that their involvement in NISE Net benefited them professionally.

Even though university-affiliated individuals were involved in NISE Net throughout the first five years of the project, no studies were conducted that look specifically at the impact of their involvement on the public. However, some evaluation studies have been conducted looking at what university-affiliated individuals learned through NISE Net activities about how to engage a public audience in learning about nano. These evaluations provide indications of whether NISE Net has increased the capacity of university-affiliated individuals to reach a public audience through their offerings. Therefore, the next few sections of this chapter discuss what university-affiliated individuals viewed as the professional benefits of participating in NISE Net. The two main themes identified about the ways university-affiliated individuals felt participation in NISE Net benefited them are the following:

- University-affiliated individuals reported that a benefit of NISE Net participation was the chance to participate in informal education learning experiences and to teach the public about their research.
- University-affiliated individuals reported that a benefit of NISE Net participation was the chance to learn about science communication and informal science education through professional development activities.

[21] Groups working with NISE Net were called "nanoscience colleges / universities" if they focused on nanoscale science, engineering, or technology.

University-affiliated individuals reported that a benefit of NISE Net participation was the chance to participate in informal education learning experiences and to teach the public about their research.

Across multiple evaluation reports university-affiliated individuals indicated that one of the benefits of participating in NISE Net was a chance to present information about their research to the public. For many university-affiliated individuals, a reason they became involved in informal education nano learning experiences was to create a better informed public using their knowledge as content experts (Goss & Kollmann, 2011; St. John, et al., 2009a). Some university-affiliated individuals also reported that an additional benefit of interacting directly with the public was hearing the public's reactions to their research (Kollmann & Goss, 2011; St. John, et al., 2009a). According to the *Interview Study with Scientists*, participation in NISE Net not only allowed university-affiliated individuals to participate in informal education nano learning experiences, it also allowed them to gain skills in this arena and help them better understand how to become involved with their local informal education institutions (St. John, et al., 2009a).

These findings are similar to those reported in the evaluation of the *DragonflyTV: Investigating the Nanoworld*, a non NISE Net project where participating university-affiliated individuals reported they became involved in order to educate the public about their research. However, the evaluation found that these university-affiliated individuals were sometimes frustrated with DragonflyTV producers when they were not able to make decisions about what content they would present to the public through the TV show (Robles, et al., 2009). Thus far, NISE Net evaluations have not indicated that university-affiliated individuals are feeling this frustration, although the potential for such frustration is something that NISE Net may want to remain aware of in the future.

University-affiliated individuals reported that a benefit of NISE Net participation was the chance to learn about science communication and informal science education through professional development activities.

According to university-affiliated individuals, a benefit of their participation in NISE Net was not only that they got a chance to provide informal education nano learning experiences, but also that they got a chance to learn. For many university-affiliated individuals, NISE Net's professional development opportunities for scientists and researchers were one of the key reasons they became involved with the Network. Some university-affiliated individuals even reported that being able to participate in NISE Net changed or expanded their career focus (Ewing, 2009; Kollmann, 2009; St. John, et al., 2009a). For other university-affiliated individuals, participation of any kind in the Network improved their ability to communicate science research or to understand informal science education pedagogy such as inquiry (Ewing, 2009; Goss & Kollmann, 2009; Kollmann, 2009; St. John, et al., 2009a). Not only did university-affiliated individuals feel that they learned through their participation in NISE Net, they also reported that this was one of the aspects of their participation that they valued the most (Goss & Kollmann, 2009; Kollmann, 2009).

Evaluation reports of other projects also found that learning about informal science education was something university-affiliated individuals appreciated most about their participation. The evaluations conducted for the *Portal to the Public* found that scientists were happy to participate in trainings offered to prepare them for doing outreach, and that scientists were especially interested in learning techniques for engaging the public in science content (Schatz & Russell, 2008). According to the evaluation of the Current Science & Technology project at the Museum of Science, even though participating scientists did not receive professional development as a

part of their involvement, they thought that this could be a valuable aspect of participation if it helped them think about how to best present their research to the public (Storksdieck, et al., 2006). These findings all highlight the importance of providing professional development to university-affiliated individuals not only because it may improve their ability to present science content to the public, but also because university-affiliated individuals value the chance to learn about how to best provide informal education learning experiences.

Finding 3: The ways that university-affiliated individuals have benefited from their involvement in NISE Net may have had positive impacts on the public.

While NISE Net evaluations and data sources have not directly recorded the impacts of university-affiliated individuals' participation in informal education nano learning experiences on the public, the benefits that university-affiliated individuals have reportedly derived from their participation in the Network may indicate ways that the public have been impacted. The two main themes related to the impact that university-affiliated individuals' participation may have had on the public are:

- University-affiliated individuals reported that their involvement in NISE Net has increased their interest in providing informal education nano learning experiences.
- University-affiliated individuals reported that their involvement in NISE Net has increased their science communication skills.

University-affiliated individuals reported that their involvement in NISE Net has increased their interest in providing informal education nano learning experiences.

Many university-affiliated individuals who participated in NISE Net reported that their involvement has increased their interest in providing informal education nano learning experiences to the public. While some evaluation reports indicate that participation in NISE Net increased university-affiliated individuals' desire to provide informal education nano learning experiences, the *Nanoscale Education Outreach (NEO) Evaluation* reported that almost all evaluation respondents (94%, 31 of 33) actually conducted some kind of nano learning experience such as delivering a presentation after participating in the NEO workshop[22] (Ewing, 2009; Kollmann, 2009; St. John, et al., 2009a). Additionally, many NEO participants reported that they hoped to continue their involvement in NISE Net (Ewing, 2009).

If university-affiliated individuals become inspired to increase their involvement in informal education learning experiences because of their association with NISE Net, it is possible that these findings could mean that more members of the public will have a chance to learn some science or engineering content directly from scientists and engineers. However, it is currently unknown how many public participants are interacting with university-affiliated individuals as a part of their interaction with NISE Net products and how, if at all, learning through an interaction with a university-affiliated individual differs from learning through an interaction with a museum educator.

[22] Nanoscale Education Outreach (NEO) was a workshop for graduate students designed to enhance their public engagement and inquiry skills, which was carried out during Years 1 and 2 of NISE Net.

University-affiliated individuals reported that their involvement in NISE Net had increased their science communication skills.

University-affiliated individuals reported that NISE Net not only increased their interest in providing informal education nano learning experiences for the public but that it also increased their skills in interacting with the public. According to the *Interview Study with Scientists*, most university-affiliated individuals (15 of 19 participants) felt that being a part of NISE Net had increased their ability to be an effective presenter of nano content (St. John, et al., 2009a). Other NISE Net evaluations have indicated that university-affiliated individuals felt participation in professional development activities for scientists and researchers increased their communication skills (Ewing, 2009; Goss & Kollmann, 2009). University-affiliated individuals specified that they learned about the following from their participation in professional development activities:

- Presenting research to non-science audiences (Ewing, 2009; Goss & Kollmann, 2009),
- Presenting science research to other scientists (Goss & Kollmann, 2009),
- Educational research (Ewing, 2009), and
- Theories of inquiry based learning (Ewing, 2009).

These findings indicate that participation in NISE Net increased university-affiliated individuals' understanding of how to present their research to different audiences. This may have a positive impact on the public by increasing the chance that individuals are able to learn science and engineering content when they interact with university-affiliated individuals. However, the extent of the impact on the public is unknown.

Finding 4: There are opportunities for NISE Net to expand outreach opportunities for university-affiliated individuals.

While NISE Net has taken many steps to ensure that university-affiliated individuals are able to effectively participate in informal education nano learning experiences with the public, there are still opportunities to increase the number of university-affiliated individuals involved in the Network and to increase their impact on the public. The areas of opportunity for involvement of university-affiliated individuals in informal education nano learning experiences include the following:

- Some university-affiliated individuals felt that NISE Net could provide them with more opportunities to participate in content development.
- Some university-affiliated individuals felt that they would like to increase their involvement in informal education learning experiences with the public.

Some university-affiliated individuals felt that NISE Net could provide them with more opportunities to participate in content development.

Reports from Years 1 – 5 of the Network indicate that some university-affiliated individuals felt that it would be beneficial to NISE Net if they were more involved in the product development process. For example, some university-affiliated individuals who took part in the *Reach and Impact Study* reported that they felt NISE Net should involve them more closely in developing new products (St. John, et al., 2009c). Additionally, according to the *Overview of the NISE Net Evaluation* report, some university-affiliated individuals were concerned about the scientific quality of NISE Net materials (St. John, et al., 2009b). It is unclear how widespread these feelings are among university-affiliated individuals.

The findings cited above indicate that university-affiliated individuals have a vested interest in the nano content presented to the public and they are not just interested in interacting directly with the public through informal education nano learning experiences. University-affiliated individuals are also interested in thinking about what is presented to the public and how it is presented. Additionally, these findings illustrate a concern about the accuracy of the information presented to the public as well as an interest in helping NISE Net think about the content focus of Network products.

To address these concerns, in Year 5 NISE Net created the Content Steering Group composed of ISE professionals, university-affiliated individuals, and others. This group created the NISE Net Content Map to guide the development of products created in Years 6 – 10. This group also reviewed the Year 6 mini-exhibit prototypes. Because the Content Steering Group is new to NISE Net, no studies have been conducted yet to understand whether university-affiliated individuals feel that this group addresses their concerns about the nanoscale science, engineering, and technology content disseminated by NISE Net.

Some university-affiliated individuals would like to increase their involvement in informal education nano learning experiences with the public.

While many partner organizations are working with university-affiliated individuals to provide informal education nano learning experiences, some partners and university-affiliated individuals felt that there is an opportunity for NISE Net to increase university-affiliated individuals' involvement. Results of the Inverness Research Inc. *Summary of Interviews with Regional Workshop Participants* indicated that partners felt NISE Net had been more successful at creating connections between different ISE institutions than between these institutions and scientists (St. John, et al., 2009d). Additionally, according to the *NISE Net Interview Study with Scientists*, only about half the participants felt that NISE Net was succeeding as a service organization for scientists and some participants felt that NISE Net needed to involve more scientists in its work (St. John, et al., 2009a).

These feelings may have been prompted for a number of reasons. First, university-affiliated individuals and ISE institutions may need more help forming partnerships with each other as the Inverness Research Inc. *Regional Workshop Interviews* found that some partners wanted more help from NISE Net in connecting with scientists (St. John, et al., 2009d). Second, ISE institutions may be uncomfortable working with scientists and wary of forming partnerships. For example, the 2008 and 2009 Regional Workshop evaluations found that the workshops increased participants' comfort working with scientists, but that 41%-43% of partners still did not feel entirely comfortable working with scientists to provide informal education nano learning experiences for the public (Grack Nelson, 2009; Grack Nelson & Philippe, 2008). Third, NISE Net may need to involve more university-affiliated individuals in its work or find more university-affiliated individuals who are interested in providing informal education learning experiences. There is evidence to suggest that NISE Net is still unknown to many scientists (St. John, et al., 2009a).

It is important to note that some of the issues cited above may already be dissipating. There is evidence that many NISE Net partner institutions were working closely with universities on nano education efforts during Year 5. Data collected during the Year 5 Site Visits show that most of the visited partners (18 of 26) had formed a partnership with a local college or university. Additionally, 12 partners relied on universities as a resource for gathering ideas about nano learning experiences that could be implemented with the public (Grack Nelson & Ostgaard, 2010b). Because the partners who received a site visit were not representative of the entire

Network, it is difficult to determine how widespread such practices are within NISE Net. It is possible that Network changes, such as the creation of the RISE work group and professional development products, may have helped to increase partnerships between ISE institutions and universities making such partnerships more common than in earlier years of the Network.

Conclusion

Since the beginning of NISE Net, the inclusion of scientists and engineers was determined to be vital to the Network's development. One reason for this was that scientists and engineers could provide content knowledge about the new and emerging field of nanoscale science, engineering, and technology. Scientists and engineers were also seen as valuable informal education nano learning experience partners.

The purpose of this chapter was to look across sources of information to understand the impact of scientist and engineer involvement in Years 1-5 of the Network on the public. However, it was decided that the phrase "scientists and engineers" was not an accurate descriptor of this group because in many cases NISE Net reports used the phrase "scientists and engineers" not only to describe professional scientists and engineers but also to describe science and engineering students, outreach coordinators, and others. Additionally, it was discovered that a vast majority of the "scientists and engineers" who were a part of NISE Net came from colleges and universities while very few were from industry. For these reasons, it was decided that this chapter would not look at the impact of "scientists and engineers" on the public but instead look at the impact of "university-affiliated individuals" on the public.

While university-affiliated individuals filled a number of roles during Years 1 – 5 of the Network, some individuals hope to increase their participation.

Findings about the involvement of university-affiliated individuals during the first five years of NISE Net indicate that these individuals filled a number of different roles. University-affiliated individuals participated in the Network as content advisors, product developers, and public presenters and took on other kinds of informal education learning experience roles. Additionally, university-affiliated individuals became involved in NISE Net by participating in various professional development activities intended for scientists and researchers about science communication and inquiry learning. These opportunities included conference sessions, internships, and workshops about communicating science content to the public as well as informal science education pedagogy.

Analysis of data sources indicates that within these roles university-affiliated individuals had differing levels of involvement. Some university-affiliated individuals participated in NISE Net only by adding their name to the MRS scientist database. Others participated in NISE Net only by attending a one-to-two hour conference session or answering a few questions for content developers about nano content. On the other hand, some university-affiliated individuals were deeply involved in NISE Net. These university-affiliated individuals participated by speaking and presenting at various NISE Net events, advising for multiple months or years on individual products or the Network as a whole, or becoming a Tier 1 partner who received NISE Net grant money to carry out the work of the Network.

Despite these varying levels of possible engagement in NISE Net, some university-affiliated individuals indicated that they would like to increase their involvement. Some professional development participants voiced interest in applying the skills and knowledge they had gained from their workshops and internships to work within one of the NISE Net ISE institutions. Some university-affiliated individuals, who participated in informal education nano learning experiences with NISE Net, expressed a desire to participate in longer-term opportunities with

NISE Net. Other university-affiliated individuals wanted more of a role in the content and product development process.

These findings indicate that there is a desire among some university-affiliated individuals currently participating in NISE Net to broaden and deepen their involvement. Therefore, NISE Net may want to consider increasing the number of short-term and long-term participation opportunities it provides for university-affiliated individuals during Years 6- 10 of the Network. This could include providing more opportunities for university-affiliated individuals to take part in nano learning experiences both within informal science education institutions as well as increasing the capacity of university-affiliated individuals to conduct these activities at their own sites. The Network may also wish to provide more opportunities for university-affiliated individuals to advise and help NISE Net develop public products about nanoscale science, engineering, and technology.

Additionally, these findings raise possible research and evaluation questions. It is evident that more university-affiliated individuals were reached by NISE Net through less formal professional development drop-in activities and educational opportunities such as conference presentations than formalized professional development activities requiring registration such as workshops and internships. However, it is unknown what impact the more and less formalized professional development activities have on university-affiliated individuals' participation in NISE Net. Therefore, NISE Net may want to study what types of professional development opportunities are most likely to prompt university-affiliate individuals to participate in informal education nano learning experiences. Second, it was found that while many ISEs are currently working with scientists and engineers, others are hesitant to do so. Therefore, it may be useful to NISE Net to study the barriers that discourage university-affiliated individuals and ISE institutions from partnering with each other.

University-affiliated individuals feel that their involvement in NISE Net benefits them, but it is unclear how their involvement impacts the public.

The findings discussed in this chapter also indicate that university-affiliated individuals feel that their involvement in NISE Net benefits them professionally. University-affiliated individuals reported that their involvement in NISE Net gave them the opportunity to provide informal education nano learning experiences and to share their research. Additionally, they feel that their participation in NISE Net increased their knowledge and ability to communicate nanoscale science, engineering, and technology content to the public. Finally, university-affiliated individuals reported that their involvement had increased their interest in participating in informal education nano learning experiences.

These findings are promising for NISE Net because they indicate that some university-affiliated individuals feel the Network is providing them with the support they need to present their content to the public. The findings also indicate that university-affiliated individuals feel engaged in the informal education nano learning experiences that NISE Net provides them. Therefore, it is evident that NISE Net is effectively involving university-affiliated individuals. However, as discussed above, in Years 3 and 4, some university-affiliated individuals expressed that they would like to have more opportunities for involvement in NISE Net. The Network has sought to address these concerns by creating the Content Steering Group and by encouraging partners to work with university-affiliated individuals. The Network plans to continue to encourage these partnerships in Years 6 – 10.

The findings presented in this chapter raise a series of possible research and evaluation questions. The primary question is, "Exactly what impact does the involvement of university-affiliated individuals have on the public?" Therefore, NISE Net and/or the larger ISE field could consider studying: 1) how many members of the public are learning about nanoscale science, engineering, and technology from university-affiliated individuals; 2) what the public learns when they interact with a university-affiliated individual; and 3) how, if at all, this differs from what the public learns from informal science educators. Additionally, it is currently unknown what impact university-affiliated individuals' participation in professional development activities has on the public. Therefore, NISE Net may want to study if there are any differences in the quality of informal education nano learning experiences provided by university-affiliated individuals who have and have not experienced NISE Net professional development opportunities.

3

Engaging the Public in Learning about Nano through NISE Network Educational Products

By: Jane Morgan, Christine Reich, and Juli Goss

Introduction

Nanoscale science, engineering, and technology (nano) is an emerging field where discoveries and technological innovations are only beginning to take shape. Because of the significant implications of nano for the fields of engineering, technology, and medicine, science museums nationwide have become increasingly aware of the need and opportunity to educate public audiences about this topic. However, nano is an unfamiliar topic for many science museum professionals. When considering whether to create museum programming to address this topic, challenging questions arise such as: Can a broad demographic of visitors learn about a content area that many consider to be too abstruse to understand? How would educators make decisions regarding what content to present when so much is still unknown about nano?

When several science museums and research institutions came together to promote public learning about nano through the formation of the Nanoscale Informal Science Education Network (NISE Net), they faced the risk that a general museum audience would not be able to understand the complex scientific and technical applications of nano. Regardless of this risk, professionals at NISE Net partner institutions began to develop and deliver a wide variety of educational experiences to the public that addressed the topic of nano. Over the years, NISE Net product developers and educators have shown that visitors can gain an awareness and understanding of a difficult current science and technology topic through informal education experiences offered at science museums.

As part of the NISE Net Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of the NISE Network since its inception in 2005 and provide an overarching summary to NISE Net and the broader ISE field. The *Learning about Nano* chapter summarizes what the Network has learned to date about the extent to which visitors have learned nano content through their exposure to NISE Net public educational products.

About NISE Net content learning goals

The purpose of this chapter is to summarize the evidence as provided by NISE Network evaluation reports regarding what the public learned about nano content by engaging with the educational products developed by NISE Net in Years 1-5. According to the original grant proposal, the three overarching Network Goals for content learning related to nanoscale science, engineering, and technology (nano) included the following:

1) Increase awareness of nanoscale science, engineering, and technology and its multiple potential benefits and impacts on lives and communities.

2) Increase understanding of the structure of matter and the forces at work on the nanoscale.

3) Increase understanding of societal issues, including risk assessment and abatement, and of the importance of broad citizen participation in discussions about responsible research and development of new technologies (NISE Network, 2005).

Network Goals 1 and 2 targeted the general museum visiting public while Goal 3 was focused on an audience of "more engaged science attentive adults" (NISE Network, 2005).

It is difficult to summarize succinctly what the public learned about nano given the variety of educational goals and measures that existed within NISE Net during Years 1-5. During the early years of the Network, several teams (or working groups) created educational products that were intended to engage the public in learning about nanoscale science, engineering, and technology. Some working groups worked relatively closely together and others more independently. Although all product development working groups focused on achieving the three overarching Network Goals, different groups emphasized different goals depending on their target audience and product format.

In Year 1 of the Network, the Exhibits working group and the Programs working group developed a set of "main messages" to guide the development of programs and exhibits. These main messages represented key concepts for engaging visitors in nano, and were intended to help the working groups plan their overall efforts, as well as identify learning objectives for individual products. Other working groups charged with the development of educational products, including the Visualization Lab, Forums, and Network Media, also had their own set of learning goals. The Forum group's learning goals varied somewhat from the others as it was the only group that focused extensively on the societal and ethical implications (SEI) of nano (Network Goal 3). This goal did not become a major focus of most product development beyond the Forums strand of work until the end of Year 5. Moving forward, the NISE Network is seeking to infuse societal and ethical implications (SEI) content into a broad range of public products that working groups develop in Years 6-10. For further discussion of how the NISE Net sought to educate the public about the societal and ethical implications of nano in Years 1-5, see the Review chapter *Societal and Ethical Implications*.

At the end of Year 5, the Network developed the Content Map, which outlines the key concepts that working groups should convey to the public through the nano educational products they develop. In Years 6-10 the NISE Network Content Map will act as a guide that provides working groups with articulated ideas for the development and evaluation of future NISE Net educational products. This will enable both more focused product development as well as more focused evaluations in the future.

About NISE Net working groups in Years 1-5

During the first two years of the Network, multiple "strands" of work were created and based at one of the Network's three leading institutions (Museum of Science, Exploratorium, and Science Museum of Minnesota). This management structure further evolved into "cross-network multi-institutional working groups" (St. John, et al., 2009b). The working groups included in this chapter are those that were or are responsible for the development or implementation of public products in Years 1-5, namely Exhibits, Programs, Forums, NanoDays, Visualization Lab, and Network Media. Although the Network is also made up of additional working groups (such as those focused on project management and community building), these additional groups are not included in this chapter as their work deals with professional impacts and methods for facilitating the dissemination of public products. The following is a description of the working groups dedicated to the development and implementation of educational products for the public in NISE Net Years 1-5:

- **Exhibits** – The Exhibits group develops exhibits and accompanying multimedia that address nanoscale science, technology, and engineering, and societal and ethical implications. This group began in Year 1 and continues beyond Year 5.
- **Programs** – The Programs group develops nano programming in a variety of formats, including cart demonstrations, stage presentations, facilitated activities, games, and theater. The Programs group also develops the educational materials for NanoDays. This group began in Year 1 and continues beyond Year 5.
- **Forums** – The Forums group developed the forum experience to provide participants with an opportunity to learn about and discuss the relationship between nano and their lives, society, and the environment. This group began in Year 1 and merged with the Programs group following Year 5.
- **NanoDays** – This group organizes NanoDays, a series of local events hosted by universities, museums, and other institutions to engage the public in nano learning using a programmatic kit. This group began in Year 3 and continues beyond Year 5. The educational products that comprise the kit were developed primarily by the Programs group. The kit also contains products created by Forums, Viz Lab, and other working groups.
- **Visualization Lab (Viz Lab)** – The Viz Lab group created and studied visualization techniques to help the public understand and experience the nanoscale. This group began in Year 1 and ended in Year 4.
- **Network Media** – The Network Media group developed media products intended to support the public educational goals of the Network. This group began in Year 1 and ended in Year 3. Most of the educational products produced by Network Media were later incorporated into NISE Net Exhibits. Given that the Network Media products were delivered to the public through the exhibitions, this work is not discussed separately in this chapter.

The public educational products created by these working groups were developed through a process of iterative prototyping, and included peer review, visitor evaluation, and expert/scientist review. The products are available on the Network website through the NISE Net catalog of products (www.nisenet.org/catalog). As populated at the end of Year 5, the NISE Net catalog included 78 products intended for implementation with a public audience: 51 programs, 12 exhibits, and 15 media products. Using an open-source policy, the Network

provides all blueprints, lesson plans, and materials applicable to conducting a nano-related activity or experience.

Chapter overview

This chapter of the Review, *Engaging the Public in Learning about Nano through NISE Network Educational Products*, seeks to describe what museum visitors learned about nano through the range of public products NISE Net developed in Years 1-5. Included in this description are the goals that each working group formed for the educational products they developed. Evaluation findings are discussed related to the effectiveness of the products in accomplishing their stated goals. As a result of exposure to NISE Net products, there is evidence that museum visitors nationwide who participated in NISE Net learning experiences felt more confident in their knowledge, understanding, and awareness of nano. There is also evidence that visitors learned about the nature of nano; its application in science, technology, and engineering; and its risks and benefits when interacting with specific kinds of educational products. Evidence of learning related to specific content is not seen in studies that examined the full range of experiences developed and implemented by NISE Net in Years 1-5. Lastly, this chapter outlines the development of the NISE Network Content Map, which will help to guide the content development of educational products in Years 6-10.

Methods

Listed below are the summative and formative evaluation reports that were reviewed and summarized to identify what the public learned about nano through the NISE Network products developed in Years 1-5. Each report was categorized with a primary code, which identified the main content area of the report, as well as a secondary code, which identified other content areas mentioned in the report but that were not directly relevant to the report's focus. When possible, findings from summative evaluations are highlighted in this chapter in order to provide the greatest depth and breadth of information; formative evaluation reports were only utilized in cases where summative evaluation was not available (such as with the Visualization Laboratory products and certain forums).

- Exploratorium reports:
  - *Illustrations-Human Bloodstream and Butterfly*
  - *Illustration-Zoom into Butterfly*
  - *Scale Ladders—Communicating Size and Scale*
  - *Spiral Zoom on a Nasturtium Leaf*
- Inverness Research Inc. report:
  - *Overview of the NISE Network Evaluation*
- Multimedia Research reports:
  - *Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Healthcare*
  - *Summative Evaluation of Awareness of Nanotechnology by the Museum Public*
- Museum of Science reports:
  - *NISE Net Public Impacts Summative Evaluation: Study 2*
  - *"Energy Challenges, Nanotech Solutions" Forum Formative Evaluation Summary Report*
  - *"Privacy. Civil Liberties. Nanotechnology." Forum Formative Evaluation Summary Report*
  - *"Risks, Benefits, and Who Decides?" Forum Formative Evaluation Summary Report*
- Science Museum of Minnesota reports:
  - *Year 4 Summative Evaluation of Exhibits & Programs*
  - *Year 5 Summative Evaluation of Exhibits & Programs*

Evaluators reviewed the 13 reports listed above to learn more about: 1) the public educational products developed by the Network in Years 1-5; 2) the content learning by visitors who experienced the products; and 3) the success of various product formats in engaging museum visitors in nano content. After identifying and summarizing the relevant data, evaluators looked for common themes and conclusions regarding what the public learned about nano through participation in NISE Net informal science learning experiences.

Findings from these 13 reports were also supplemented with additional analyses that were conducted using the NISE Net Forums formative evaluation database. This database was used given that only one summative evaluation study looked at visitor learning from forums. The NISE Network Forums formative evaluation database contained 980 pre/post exit surveys collected during 34 NISE Net forum events over the first five years of the Network. The forums

included in this database were collected at five different NISE Net Tier 1 institutions and covered five different forum topics.[23]

Limitations

This chapter explores the main messages and content learning objectives of Network educational products; therefore, only the work of NISE Net groups that created products for public audiences is discussed. In addition, the NISE Net has enunciated other learning goals for public audiences over time, such as fostering an interest in and seeing the personal relevance of nano, which are not the subject of this chapter, as these goals are addressed in other chapters of the Review.

This chapter is grounded in the evaluation findings of numerous public products created by NISE Net working groups. While summative evaluation findings are available for many products, formative evaluation data are also discussed. It is important to highlight that formative evaluation reports were conducted for the purpose of improving products, not to measure their success. Also, given the number of products developed by the Network, not every effort has been evaluated. Those activities that were not evaluated are not included in this chapter.

Evaluating the educational impact of the NISE Network on public audiences is an extraordinary challenge. How the public is impacted depends not only on the individual product, but also on how that product is implemented. With over 75 products created, and hundreds of institutions implementing these products across the nation and around the world, it is difficult to determine what the public is learning about nano through the full range of educational experiences that were conducted under the NISE Net umbrella. While summative evaluation findings relevant to many Network educational products are presented in this chapter, the full impact of the NISE Network on public audiences is not known.

[23] The NISE Net Forums team developed forums related to four topics that are included in the nisenet.org catalog of products. In addition, a fifth nano forum was developed, implemented, and evaluated by the Museum of Science only, but it is not included in the catalog of products. Data from the formative evaluation of this forum, however, are included within the NISE Net Forums formative evaluation database.

Findings & Discussion

There is evidence that visitors are learning about nanoscale science, engineering, and technology through educational products developed by NISE Net. Most of what is known about what visitors learned about nano through engagement with NISE Net products is found in summative and formative evaluations that looked specifically at the learning outcomes of products developed by one or two working groups. These evaluation findings are summarized below by group.

During Years 1 through 5, there was only one study that sought to measure visitor learning about nano across the working groups: the *Summative Evaluation of Awareness of Nanotechnology* conducted in Year 3 (Flagg, 2008). This study found that visitors who had been exposed to a NISE Net product self-reported a greater awareness of the risks and benefits of nanotechnology and were significantly more likely to describe an association with nano compared to individuals who had not been exposed to a NISE Net product. There was, however, no statistically significant difference between the two groups with respect to the kinds of risks, benefits, and associations that were described. The study concluded that exposure to a NISE Net product increased museum visitors' confidence in their awareness of nano; however, exposure to a NISE Net product did not appear to increase visitors' actual depth and breadth of awareness (Flagg, 2008). It should be noted that this study was conducted in Year 3, when many of the NISE Net products were still under development. Summative evaluations conducted in Years 4 and 5 provide insights on the impacts of the final versions of the educational products.

Finding 1: Visitors who participated in NISE Net exhibits and programs understood the main messages, felt more confident in their awareness of nano, and in some cases developed more sophisticated definitions of nano

An exhibit is usually an unstaffed visitor experience that may occur in many formats such as a display of objects, interactive or multimedia components, and graphic panels. A group of themed exhibits comprise an exhibition.

Programs are public interactions facilitated in-person by an educator. For example, programs in the NISE Net catalog include stage presentations for large groups, demonstrations, and facilitated activities for small groups, and classroom activities. Programs can last anywhere from 5-10 minutes (such as with brief facilitated activities) to 45 minutes (some classroom activities). At the end of Year 5, the NISE Net catalog included 51 programs and 12 exhibits.

NISE Net exhibits and programs were created with the intention of addressing the first two overall NISE Network goals: "to increase awareness of nanoscale science, engineering, and technology and its multiple potential benefits and impacts on lives and communities"; and "to increase understanding of the structure of matter and the forces at work on the nanoscale". When NISE Net was first formed, the Exhibits and Programs groups worked with Network leadership to develop a common shared set of main messages related to these goals. These main messages were changed and refined during the first five years of the Network. In Year 1 the main messages were stated as follows:

- Nano is in many realms and is both everyday and cutting edge. We all use products that have nanotechnology in them, but there are also exciting ideas about what might be

developed in the future to solve what are currently technologically intractable problems. Products range from the ordinary here-and-now to the truly innovative of the future.

- Where will nano go? Nano science and technology can take a number of paths into the future. No one is sure which paths will become reality and how nano and society will interact in the future. A look at some historical examples of scientific and technological innovations can help us imagine some of these unknowns.
- Nano means working at super small size scales to manipulate materials to exhibit new phenomena. Nano devices and technologies are driven by the behaviors of small collections of atoms and take advantage of special properties at the nanoscale. New tools have made it possible to study and work at the nanoscale.
- It's different down there! Scale matters. Gravity becomes less important, while electrostatics, friction, increased surface area, and kinetic motion become very important at the nanoscale. This gives us big problems if we continue to think with our macroscale experiences and use our macroscale rules, but it also provides us with big opportunities if we exploit what's unique at the nanoscale.
- Nano is a people story. Many different kinds of people work on interdisciplinary teams to investigate nano and make nano products. The potential of nano science, technology, and engineering are greatly broadened by their interdisciplinary natures.
- Will nano affect you? Nanotechnology has many social and political implications that are important for us to consider in advance. Possible important issues include job shifts, health, ethics, toxicity, privacy, security, the human/machine interface, environmental safety, and environmental cleanup.

Because the Exhibits and Programs teams shared similar main messages and a common target audience, and were all evaluated by the Science Museum of Minnesota, the products from the two groups were combined for evaluation purposes.

Two summative evaluation studies were conducted in Years 1 through 5 that examined the content learning outcomes of NISE Net Exhibits and Programs: The *Year 4 Exhibit and Program Summative Evaluation* and the *Year 5 Exhibit and Program Summative Evaluation*. Findings from these evaluations are summarized below.

The *Year 4 Exhibit and Program Summative Evaluation* focused on visitor learning with respect to the main messages that had been developed by the Exhibits and Programs working groups. This evaluation surveyed visitors after they had participated in one of the four NISE Net programs that were included in the study. These programs were hosted at the Science Museum of Minnesota and the Oregon Museum of Science and Industry.

To assess whether visitors were taking away the intended messages for particular programs (that were based on the main messages developed by NISE Net), visitors who participated in the Year 4 study were asked to describe, after participating in a NISE Net program or exhibit, what the deliverable was about. When prompted, four-fifths (84%) of the 375 visitor responses articulated a message that corresponded to the specific messages of the program in which the visitors participated. As another measure, visitors were asked to self-report on whether participating in a particular program influenced their awareness of nanotechnology. Across the four programs that were analyzed in the Year 4 summative evaluation, 66% of participants reported that the program had greatly influenced their awareness of nanotechnology (Ellenbogen, Cohn, & Onkka, 2009).

In the *Year 5 Summative Evaluation of Exhibits and Programs,* Bequette, Svarovsky, and Ellenbogen (2011) found further evidence to suggest that NISE Net exhibits and programs increased visitors' overall awareness of nano. In their evaluation, Bequette et al. (2011) assessed whether museum visitors' awareness of nano was heightened by exposure to a NISE Net deliverable. For the purposes of the evaluation, "nanoawareness" could be achieved if a visitor articulated any one of the following four nanoawareness ideas:

1) Nanometer-sized things are very small and often behave differently than larger things do.
2) Nanotechnology is manipulating matter with control at a small (size) scale.
3) Nanoscience and nanotechnology lead to new applications.
4) Like any technology, nanotechnology has risks and benefits.[24]

Most frequently, the primary learning objectives of the exhibits and programs evaluated in the Year 5 study aimed to increase visitors' understanding of nanoawareness ideas 1, 2, or 3, with particular emphasis on idea 1.

In contrast to the Year 4 study, the *Year 5 Exhibits and Programs Summative Evaluation* studied visitor learning after participating in either exhibitions or programs. The Year 5 also utilized both quantitative and qualitative data collection methods, relying on unmatched pre- and post-surveys as well as in-depth interviews. Exhibition data were collected at the Museum of Science (Boston, MA), Oregon Museum of Science and Industry (Portland, OR), the Museum of Discovery (Little Rock, AR), and the Arts and Science Center (Pine Bluff, AR). Program data were collected at the Science Museum of Minnesota.

The Year 5 study suggests that NISE Net programs and exhibits were successful in informing visitors about multiple aspects of nano. The evaluation illustrates that visitors who had seen the exhibition or attended programs showed a statistically significant difference from visitors who had not seen the exhibits or programs in their confidence in their ability to explain something about nano, naming a nanoscale sized object, describing how nano objects behave differently, describing a process used to produce objects at the nanoscale, naming applications of nano, and explaining some of the risks and benefits of nano.

When asked to define nano using an open-ended prompt, visitors who attended the exhibition, however, showed no statistically significant differences as compared to visitors who had not attended the exhibition in the definition of nano they provided. There was a statistically significant difference in the types of definitions offered by visitors who saw the programs versus those who did not. When asked to define nano in a different way, however, exhibition visitors did demonstrate an enhanced operational definition of nano. Visitors were asked to sort everyday objects into those that use nanotechnology and those that do not, and then explain their reasoning. Visitors who had seen the exhibition were more likely to discuss improved performance or special ingredients or particles as characteristics of "nano" products, and were less likely to sort by rules like "only electronic things are nano" or "only human-made things are

[24] It is important to note here that in Years 1-5 of the Network a common definition of "nanoawareness" did not exist. For the purposes of the *Year 5 Summative Evaluation of Exhibits and Programs* the NISE Net Content Steering Group developed this definition of "nanoawareness." The four statements defining "nanoawareness" are similar to the "big ideas" that are stated the Content Map. In turn, these "big ideas" are similar to the "main messages" articulated by the Network in Year 1.

nano" than those who had not seen the exhibition. (This activity was not done with program visitors.)

In summary, findings from the Years 4 and 5 summative evaluations suggest that NISE Net programs and exhibits influenced visitors' general understanding of nano. In Year 4, program participants were able to articulate the nano messages that were the focus of the programs (Ellenbogen et al., 2009). In Year 5, program and exhibit participants were more confident than visitors who did not participate in their ability to name a nanoscale sized object, to describe how nano objects behave differently, to describe a process used to produce objects at the nanoscale, to name applications of nano, and to explain some of the risks and benefits of nano. Program participants also articulated more sophisticated definitions of nano as compared to visitors who did not participate in the program, but the same was not true of exhibition visitors. Exhibition visitors did demonstrate more advanced operational definitions of nano when asked to sort objects based on whether they based on nanotechnology (Bequette et al., 2011).

Finding 2: Through participation in forums, visitors learned concepts related to nanoscale science, engineering, and technology, and about the societal and ethical issues of nano.

A forum is a type of program that targets adult audiences and features presentations by researchers (including science, technology, and social science researchers) as well as small group discussions focused on the relationship between nanoscale science, engineering, and technology and broader society. Participants register in advance and visit the museum specifically for this two to three hour event.

Forums are focused on the third Network goal, "To increase visitors' understanding of societal issues including risk assessment and abatement, and of the importance of broad citizen participation in discussions about responsible research and development of new technologies" (NISE Network, 2005). The Forums group further refined this goal to create a series of learning goals that would be specific to the work of the team. These goals, as stated in the *NISE Network Public Forums Manual*, are as follows:

- Enhance the participants' understanding of nanoscale science, technology and engineering and its potential impact on the participants' lives, society, and the environment.
- Strengthen the public's and scientists' acceptance of, and familiarity with, diverse points of view related to nanoscale science, engineering, and technology.
- Engage participants in discussions and dialogues where they consider the positive and negative impacts of existing or potential nano-related technologies.
- Increase the participants' confidence in participating in public discourse about nanotechnology and/or the value they find in engaging in such activities (NISE Network, 2007a).

To address these goals, the Forums team created four forums entitled "Risks, Benefits and Who Decides?," "Energy Challenges, Nanotech Solutions?," "Nanomedicine in Healthcare," and "Privacy. Civil Liberties. Nanotechnology." These forums are part of the catalog of products (representing 4 of the 51 products included in the catalog). The forums were developed using a collaborative and iterative process in which data-based changes were made after each

implementation. The team documented the process of planning and implementing a forum in the *NISE Network Public Forum Manual* (NISE Network, 2007a).

Only one forum program, "Nanomedicine in Healthcare," was the subject of a NISE Net summative evaluation study. This study provides important insights into the impacts of this one program. In addition to the summative evaluation, however, the majority of all forum implementations were subject to formative evaluation. To determine the overall impact of the forums on the public, therefore, findings from both formative and summative evaluation studies were reviewed for this chapter.

The summative evaluation of "Nanomedicine in Healthcare" utilized a one-group pre/post survey design to study forums held at three institutions: the Exploratorium, the Oregon Museum of Science and Industry, and the Science Museum of Minnesota. This study found that forum participants came away from the program with an increased understanding of nano content. In particular, this study found that there was a statistically significant increase in the portion of the audience that understood the following: that nano operates at a submicroscopic scale (34% on pre survey, 68% on post survey) and that the properties of nanotechnology depend on size and scale (9% pre-survey, 34% post-survey). There was also a statistically significant increase in the likelihood that participants would discuss the risks of nano with friends and family (13% pre-survey, 69% post-survey), with no significant change in the likelihood that they would discuss the benefits of nano (50% pre-survey, 63% post-survey).

In addition to changes in content understandings, participants also reported that the forum familiarized them with diverse viewpoints regarding the societal and ethical implications of nanotechnology and increased their confidence in expressing their own viewpoints on this subject.

Findings from the formative evaluation of five forums[25] support the findings from the summative evaluation of this one forum. After the completion of each forum, participants were asked to rank their agreement with the statement, "I feel more informed about nanotechnology." Most surveyed participants (90%) either agreed or strongly agreed with this statement. When asked, forum participants also reported that they felt more informed about the SEI topic that was the focus of the forum (such as "privacy issues" or "energy technologies"), and about the risks and benefits related to the topic (78%), see Table 1.

[25] The NISE Net Forums team developed forums related to four topics that are included in the nisenet.org catalog of products. In addition, a fifth nano forum was developed, implemented, and evaluated by the Museum of Science only, but it is not included in the catalog of products. Data from the formative evaluation of this forum, however, are included within the NISE Net Forums formative evaluation database.

Table 1. Evaluation participants' rankings of statements about whether they felt more informed about nanoscale science, engineering, and technology and societal and ethical implications (SEI) content after the forums as found in the NISE Network Forums formative evaluation database.[26]

	N	Percent of Respondents Who "Agree" or "Strongly Agree"
I feel more informed about nanotechnology.	551	90%
I feel more informed about [the SEI topic].	551	81%
I feel more informed about the risks and benefits of [the SEI topic].	466	78%

When asked in an open-ended question what they learned from the forum that they did not know before, visitors gave a wide range of answers that reflected the multiple goals of the forums. Visitors most often reported learning about the uses of nanotechnology (17%) or about the science/technology of nanotechnology (17%). Few visitors reported learning about other aspects of nano including its societal aspects (8%) and risks (7%). It should be kept in mind that in response to the open-ended question, most visitors only listed one thing that they learned that they did not know before participating in the forum. What visitors reported in these open-ended comments, therefore, reflects the learning that was the most salient or important to them as learners and not the full extent of the content they learned during the forum.

Combined, findings from both the formative and summative evaluation of NISE Net forums demonstrate that through forums, participants learned about both content related to nanoscale science, engineering, and technology, as well as its societal and ethical implications.

Finding 3: Through participation in NanoDays, visitors felt more confident in their awareness of nano although the event did not appear to influence their understanding of specific nano concepts.

NanoDays is a nationwide festival of educational programs about nanoscale science and engineering and its potential impact on the future. NanoDays events are organized by NISE Net partner institutions and now take place at over 200 science museums, research centers, and universities across the country from Puerto Rico to Hawaii.[27] NanoDays events typically feature hands-on activities and demonstrations and may also include speaker events, theater presentations, art shows, lab tours, lectures, deliberative forums, and science cafes.

It is estimated that NanoDays reached approximately 425,107 people during NanoDays 2009 and 472,835 people in 2010 (Pattison, et al., 2011; Reich & Goss, 2009b). These numbers were derived using similar methods. Two data collection instruments were utilized to generate an

[26] Forum participants were asked to rank these statements on a scale of 1 to 4 where 1 is "strongly disagree," 2 is "disagree," 3 is "agree," and 4 is "strongly agree."

[27] While several communities conducted NanoDays events in prior years, the first nationwide week of events took place in 2008 with more than 100 institutions participating. This has grown to more than 200 events over the past years.

estimate of the total number of public encounters during NanoDays: the counting protocol and the NanoDays report. The counting protocol was used to generate estimates for the number of people who participated in a NISE Net program or activity of a certain type. The NanoDays report was used to capture the number of activities of different program types that were hosted across all of the participating institutions. Combining these data provides an estimate of the number of people who experienced NanoDays activities across the 200 institutions that received NanoDays kits. (# of activities x average # of people per activity= total number of participants).

NanoDays draws on numerous NISE Net public products along with the NanoDays kit. The kit includes a planning guide along with the materials and supplies necessary to conduct NanoDays activities developed by NISE Net. Each NanoDays kit activity went through iterative prototyping and formative evaluation with visitors. Individual educational products developed for NanoDays were formatively evaluated through the work group that created them. Institutions that choose to host NanoDays events can use the NanoDays kit along with any other nano-related activities that are not included in the kit (including those created by NISE Net that are available through the nisenet.org catalog of products) to customize and tailor the event to the interest and needs of their visitors.

The NanoDays kit, while an essential part of NanoDays events, represents only a portion of the activities conducted as a part of the NanoDays events held across the nation and around the world. Studies estimate that roughly half of the activities implemented as part of NanoDays use NISE Net educational products (Pattison, et al., 2011; Reich & Goss, 2009a). Given that the kit represents only a portion of the activities that are implemented as part of the NanoDays events, findings from the formative evaluation of individual kit products do not provide a true indication of what visitors learned through participation in NanoDays events. For this reason, discussions of the NanoDays content learning outcomes draw exclusively on the one summative evaluation that examined the impact of NanoDays on visitor awareness of nano.

The Year 4 *NISE Net Public Impacts Summative Evaluation Pilot Nanoawareness Study (The Year Nanoawareness Study)* sought to determine if visitors exposed to NanoDays activities demonstrated greater nanoawareness compared to visitors who had not been exposed. Data were collected by means of an online survey with 80 treatment group members (visitors exposed to NanoDays) and 75 control group members (visitors who had not been exposed to NanoDays) at four Tier 2 institutions (Kiser & Benne, 2009).

The *Year 4 Nanoawareness Study* found that although many NanoDays participants reported that the event increased their awareness, knowledge, and understanding of nanotechnology (see Table 2), NanoDays visitors' actual awareness of nanotechnology, knowledge about the topic, and understanding of its applications did not significantly differ compared to individuals who had not attended NanoDays.

NanoDays participants who remembered a specific NanoDays activity were asked to "Please describe how the [nano-activity] experience influenced your awareness of nanotechnology" (Kiser & Benne, 2009, p. 22). Respondents reported that their NanoDays experience influenced their 1) awareness of nanotechnology (28%); 2) knowledge of nanotechnology (22%); and 3) understanding of applications (18%), see Table 2.

Table 2. Evaluation participants' descriptions of how the experience influenced their awareness of nanotechnology as reported through an open response question.

Codes	Percent of Responses by Coded Category (n=49)
Left blank	29%
Increased my awareness of nanotechnology/wasn't aware of nanotechnology before	28%
Increased my knowledge of nanotechnology	22%
Increased my understanding of the applications of nanotechnology	18%
Other	27%

Note. Adapted from "NISE Net public impacts summative evaluation: Pilot nanoawareness study year 4 report," by B. Kiser and M. Benne, 2009.

However, when treatment group respondents (those who had been exposed to NanoDays activities) were asked in the online survey to describe the nanoscale and to indicate what they knew about its applications, treatment group respondents were no more likely to report having heard about nanotechnology or to indicate that they had heard about a certain application of nanotechnology compared to control group respondents. Additionally, although treatment group respondents were significantly more likely to report an awareness of the benefits of nanotechnology compared to control group respondents, treatment group respondents were no more likely to report an awareness of its risks. In terms of knowledge related to the nanoscale and the material properties that are different at the nanoscale, NanoDays visitors' descriptions of the nanoscale and material properties did not differ significantly from control group responses.

Finding 4: Early versions of Viz Lab products were not very successful in communicating each product's intended main messages to visitors.

The Visualization Laboratory (Viz Lab), based at the Exploratorium, created and studied effective and innovative visualization techniques for understanding and experiencing the nanoscale. Central to the lab's research and development was the question, "How do we visualize the nano world and the forces that dominate it?" While no summative evaluations were conducted to consider the effectiveness of Viz Lab products in increasing visitors' understanding of nanoscale science, engineering, and technology, there are several formative evaluations that provide some insight into the impact of specific Viz Lab products. It is important to note that the formative evaluation reports do not evaluate the effectiveness of specific formats in promoting visitor awareness and understanding of nano; therefore, successful outcomes for visitor understanding as a result of Viz Lab products cannot be conclusively identified. In addition, the products that were formatively evaluated were revised and modified based on evaluation findings; it is not known how these revisions affected subsequent visitor outcomes.

Following is a description of four Viz Lab products that were formatively evaluated as individual products:

Zoom into a Nasturtium Leaf - The interactive media zoom, *Zoom into a Nasturtium Leaf*, allows visitors to magnify the familiar object of a leaf. A component of a life science exhibition, *Zoom into a Nasturtium Leaf* is an interactive media piece that seeks to educate visitors about how a nasturtium leaf repels water. After interacting with the media piece and viewing images of

the nasturtium leaf at progressively higher levels of magnification, over half (15 of 29) of sampled visitors were able to articulate the exhibit's main message that "nanocrystals on the surface of nasturtium leaves have water-repelling properties" (Klinger, 2009, p. 5).

Scale Ladder - The scale ladder poster was developed to depict the nanoscale and to help visitors answer the question "Where is nano in the scale of things?" The print media scale ladder poster presents images of familiar or labeled items ordered along a ruler that spans multiple scales. In this way, the scale ladder provides visitors with familiar size references for each scale category: macro, micro, and atomic. A formative evaluation of the effectiveness of the scale ladder in conveying a correct understanding of the size of nano found that after spending five minutes looking at the poster, only 9% (3 of 34) of all visitors mentioned that nano is bigger than an atom and smaller than a cell, the definition the poster was designed to communicate (Ma, 2007b).

Zoom into the Human Bloodstream and Zoom into a Butterfly Wing - To demonstrate the main message that "Everything is made of atoms," three illustrations were created to visually zoom into familiar objects including a human heart, a butterfly's wing, and a laptop computer. Ma (2007a) conducted a formative evaluation of the first version of two illustrations (human bloodstream and butterfly wing) in order to gauge what visitors saw as the main message of the two illustrations. Most visitors thought the two illustrations showed how one thing is made of other things. When asked what they thought the poster was trying to show, most (9 of 14 or 64%) thought that the poster was trying to show what things are made of. About half of evaluation participants (8 of 14) recognized the depiction of atoms used in the illustrations. In addition, visitors were more likely to recognize the depiction of macroscale objects in both posters, and to have more difficulty identifying microscale and nanoscale objects. After viewing the posters, visitors were asked to complete the sentence, "Everything is made of_____." Forty-three percent (6 of 14) of visitors said atoms and/or molecules (Ma, 2007a).

Overall, the formative evaluations of Viz Lab products suggest that the early versions of these products were not very successful in communicating each product's intended main messages to visitors. Through an iterative process, Viz Lab products were modified and refined in order to better achieve their learning objectives. Because summative evaluations were not conducted on the final deliverables it is not possible to determine whether the final versions of the products were more successful than the original prototypes in helping visitors to visualize the nanoscale and the forces that dominate it.

Conclusion

Nanoscale science, engineering, and technology (nano) is an emerging field where discoveries and technological innovations are only beginning to take shape. Because of the significant implications of nano for the fields of engineering, technology, and medicine, science museums nationwide have become increasingly aware of the need and opportunity to educate public audiences about this topic. However, nano is an unfamiliar topic for many science museum educators. When considering whether to create museum programming to address this topic, challenging questions arise such as: Can a broad demographic of visitors learn about a content area that many consider to be too abstruse to understand? How would educators make decisions regarding what content to present when so much is still unknown about nano?

Findings from formative and summative evaluations of public products indicate that the Network achieved varying levels of success in conveying messages and learning goals to the public. Across almost all products, however, (with the exception of Viz Lab products where only formative evaluations were conducted), there is evidence that visitors felt more informed about nano after their participation in learning experiences with NISE Net educational products. Some visitors also developed more sophisticated definitions of nano based on their interactions with programs, exhibits, and forums. Through forums, visitors demonstrated that they learned more about the potential risks of nano, and through certain programs, visitors learned about the properties of matter at the nanoscale and about the applications of nano.

While studies examining the work of specific working groups and educational products provide evidence of nano learning among the participating visitors, studies that examined a broad range of NISE Net learning experiences (such as the *Year 4 Nanoawareness Study* and the *Summative Evaluation of Awareness of Nanotechnology* conducted in Year 3) did not draw the same conclusion. These studies found that visitors were generally more confident in their awareness of nano or likely to report that they were more aware of nano after participating in NISE Net learning experiences, but did not demonstrate statistically significant differences in their knowledge or understanding of specific concepts when compared to visitors who did not participate in learning experiences that featured NISE Net products.

There are a variety of plausible explanations that could explain the difference in findings between those studies that examined specific products and those that examined a broad range of products. All of these explanations connect to the challenge that it is difficult to detect specific content learning when there is a diverse range of experiences and content to which visitors are exposed. First, the studies that examined experiences that used products across a variety of working groups were conducted in more naturalistic settings. In these studies, educators and other professionals could modify and implement the products as much as they liked. Other NISE Net evaluation studies have shown that educators do make modifications to the products prior to implementation (Grack Nelson & Ostgaard, 2010b; Pattison, et al., 2011; Reich & Goss, 2009a). These modifications could impact the outcomes of NISE Net learning experiences. Second, as discussed above, not all of the educational products developed during the first five years of the Network shared the same learning goals. This makes it difficult to detect increases in specific content areas when the possible content that visitors were exposed to and had the opportunity to learn was quite varied, and there were few commonalities between the experiences of each individual visitor. Finally, studies of Network activities related to public learning about nano have also shown that the partner institutions use a variety of educational products during NanoDays and throughout the year, including products that were not created by NISE Net. These products may also have their own set of learning goals that differ from those of the NISE Net working groups.

In Years 6 through 10, it may be possible to conduct studies that examine learning outcomes that cut across a wide range of learning experiences. The NISE Network recently created a Content Map, with the goal of establishing a plan and guiding concepts for educational product development and evaluation in Years 6-10 (NISE Network, 2010e). The NISE Network Content Map presents key science content ideas for informal science education in nanoscale science, engineering and technology. NISE Net programs, exhibits, media, and other educational experiences engage the public in these ideas (Bequette, et al., 2010). The Content Map is organized around four ideas:

1. **Small and different—**Nanometer-sized things are very small, and often behave differently than larger things do.
2. **Manipulating matter—**Scientists and engineers have formed the interdisciplinary field of nanotechnology by investigating properties and manipulating matter at the nanoscale.
3. **New knowledge and innovations—**Nanoscience, nanotechnology, and nanoengineering lead to new knowledge and innovations that weren't possible before.
4. **Risks and benefits—**Nanotechnologies have costs, risks, and benefits that affect our lives in ways we cannot always predict.

Moving forward, the NISE Net Content Map will guide educational product development in Years 6-10 of the Network and serve as a valuable measure that evaluators can use to determine the effectiveness of NISE Net products in accomplishing the Network's public impact goals. The Content Map will also provide a solid foundation for the Network's learning progression research study that will take place in Years 6 through 10.

4

Engaging the Public with Societal and Ethical Implications Content through NISE Network Products

By: Elizabeth Kunz Kollmann

Introduction

As part of the NISE Network's Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of NISE Net since its inception in 2005 and provide an overarching summary to the NISE Network and the broader ISE field about the impacts of various foci of the Network on the public. The *Societal and Ethical Implications* chapter strives to provide insights on the public impact of including societal and ethical implications content in NISE Net Years 1-5 educational products. This chapter begins by examining why NISE Net originally decided to include societal and ethical implications of nanotechnology (SEI) content in its products and how the NISE Net SEI goals have changed over the first five years of the Network. It then examines how NISE Net products that include this content impact the learning, engagement, and behaviors of the public. Finally, it examines opportunities for NISE Net to expand inclusion of SEI content in its products.

The origins of the inclusion of societal and ethical implications of nanotechnology in NISE Net

A goal of NISE Net from its beginnings has been to educate the public about not only the science, engineering, and technology aspects of nano but also about its societal and ethical implications (SEI). SEI covers the relationship between nanoscale science, engineering, and technology (nano) and our lives, society, and the environment. It examines the tradeoffs among the costs, risks, and benefits of developments in nano, and also the role different entities (such as citizens, consumers, and government officials) play in decisions related to the use and implementation of nano. During Year 1 of NISE Net, societal and ethical implications goals for public participants included the following:

- *Visitors will have increased awareness of nanoscale science, engineering and technology and its multiple, potential benefits and impacts on lives and communities.*

- *Visitors will have increased understanding of societal issues including risk assessment and abatement, and the importance of broad citizen participation in discussions about responsible research and development of new technologies* (NISE Network, 2005).

When NISE Net began, these goals, particularly the second one, were the focus of the NISE Net Forum group. Other products produced in Years 1 – 5 of NISE Net also covered the first goal, describing new applications or developments made possible because of nanotechnology and their potential benefits to society. These products, however, did not always discuss the broader impacts of the science and technology, including possible risks, conflicts between adoption of the new technologies and personal values, or effects on the environment. After a few years of existence, NISE Net products beyond forums did start to include both goals one and two into their content. These were considered prototype test cases.

Throughout the first five years of NISE Net, public impact goals have evolved and changed based on the work and learning of the Network, but the Network has retained goals related to the societal and ethical implications of nano. The NISE Network Content Map developed in Year 5 by the Content Steering group included the following as one of four key content ideas:

> *IDEA 4: Nanotechnologies have costs, risks, and benefits that affect our lives in ways we cannot always predict.*
> *4.1 Through our choices as consumers and citizens, we affect the development of nanotechnologies.*
> *4.2 Governments, companies, and individuals can all be involved in guiding the development and regulation of nanotechnologies.*
> *4.3 A nanotechnology that benefits one person or group may put others at risk.*
> *4.4 Technologies and society are closely interconnected. Change in one area influences change in the other.* (Bequette, et al., 2010)

As NISE Net continues its work during Years 6-10, the educational product development teams will be guided by the Content Map in defining learning goals for public audiences, and their work will reflect an increased focus on developing products that engage public audiences in learning related to the societal and ethical implications of nano. The teams also plan to continue to expand the types of products that address SEI beyond forums, and to expand the target audiences of SEI products beyond adults.

The chapter focuses on the forums because this was the focus of the NISE Network SEI work in Years 1 – 5.

When NISE Net began, it only attempted to achieve both societal and ethical implications goals (discussion of the benefits of nanotechnologies and the risks) through the forum programs. However, later on, these goals were also integrated into other types of products. By the end of Year 5, NISE Net tried to achieve SEI goals through some of their exhibits, programs, and media as well as the forums. However, these were only pilot tests, and the SEI content focus in Years 1 – 5 remained the forum program. The focus of this chapter is therefore the impact of the NISE Net forum programs on the public because:

1. The forums were the product through which NISE Net focused their SEI efforts in Years 1 – 5;
2. The forums always contained SEI content; and
3. Over half of each forum program focused on SEI content.

Looking at the list of NISE Net products created in Years 1-5 included in the nisenet.org catalog, it becomes clear that NISE Net focused their SEI efforts on the forums in Years 1-5. This list illustrates that some product types were more likely to contain SEI content than others. For example, a larger percentage of programs (27%) contained SEI content than exhibits (8%) or media (20%) (Table 1). Even amongst the programs, there were differences in which types were most likely to contain SEI content. Of the 14 programs from Years 1-5 that contained societal and ethical implications content, six were stage presentations, four were forums, two were cart demonstrations, one was a classroom program, and one was museum theater (NISE Network Content Steering Group, 2010). Despite the fact that a greater number of stage presentations contained SEI content, a greater percentage of forums contained SEI content (forums: 100%, 4 of 4; stage presentations: 55%, 6 of 11).

Table 1. Number and percent of exhibits, programs, and media produced by NISE Net and in the nisenet.org catalog by the end of Year 5 that contained SEI content.

	Total Number of Products	Number of SEI-related Products	Percent of SEI-related Products
Programs	51	14	27%
Exhibits	12	1	8%
Media	15	3	20%
Total	78	18	23%

Note. Adapted from "2010 NISE Net product matrix internal planning document," by NISE Network Content Steering Group, 2010.

Not only do a greater percentage of the forums contain societal and ethical implications content, each forum was also more likely to contain a greater amount of this content. The amount of societal and ethical implications content in the stage presentations varies a great deal from program to program. For example, information about the stage presentations "Flying Cars" and "Wheel of the Future" indicate that "Flying Cars" has a stronger focus on SEI content. The description of the "Flying Cars" stage presentation from the nisenet.org website is the following:

> *Visitors "travel through time" with a host playing several characters: from the Future, 1900, 1945 and 1999. Visitors answer questions in a quiz about other people's predictions of future technology, and then are invited to make their own predictions.* (Liljeholm, 2011)

According to the program developer for this program, 90% of the program content is focused on SEI. In contrast, "Wheel of the Future" contains less SEI content because it attempts to provide a general overview of nano and only includes an overview of potential risks and benefits. The description of the "Wheel of the Future" stage presentation from the nisenet.org website is the following:

> *Museum visitors are contestants in a game show that encourages them to learn more about nanotechnology. The three rounds included here cover an introduction to nanotechnology; provide information on nanoparticle solar cells; and express the concerns people have for nanotechnology. New rounds of information can be plugged in as needed. The show is also designed to work with other hot topics, such as... (genetically modified food, perhaps.) Other museums have used the title Wheel of Nanoscience.* (Long, 2011)

Correspondence with the program developer about this project confirms that one-third of the program focuses on SEI.

In contrast, documents about the purpose and goals of the forum programs make it clear that the forums' focus was primarily SEI content. According to the *NISE Network Public Forums Manual*, forums "offer participants the opportunity to engage in thoughtful conversations about important issues regarding the potential societal, environmental and ethical implications of nanotechnology. They provide a vehicle for people of diverse views and backgrounds to deliberate on difficult issues and to seek a more comprehensive understanding of the topic" (NISE Network, 2007a, p. 6). Additionally, the educational and programmatic goals of forums are the following:

> ***Overarching Goal:*** *To provide experiences where adults and teenagers from a broad range of backgrounds can engage in discussion, dialogue, and deliberation by:*
>
> - *Enhancing the participants' understanding of nanoscale science, technology and engineering and its potential impact on the participants' lives, society, and the environment.*
> - *Strengthening the public's and scientists' acceptance of, and familiarity with, diverse points of view related to nanoscale science, technology, and engineering.*
> - *Engaging participants in discussions and dialogues where they consider the positive and negative impacts of existing or potential nanotechnologies.*
> - *Increasing the participants' confidence in participating in public discourse about nanotechnologies and/or the value they find in engaging in such activities.*
> - *Attracting and engaging adult audiences in in-depth learning experiences.*
> - *Increasing informal science educators' knowledge, skill, and interest in developing and conducting programs that engage the public in discussion, dialogue, and deliberation about societal and environmental issues raised by nanotechnology and other new and emerging technologies.* (NISE Network, 2007a, pp. 7-8)

This information makes it clear that in Years 1-5 the product that NISE Net focused on to achieve SEI goals was forums.

Methods

Evaluators undertook a number of steps in order to learn about the impacts of societal and ethical implications products on the public. Those steps were the following:

1. Reviewed and summarized existing NISE Net research and evaluation and data reports.
2. Reviewed and summarized evaluation reports from other projects integrating societal and ethical implications content.
3. Re-analyzed data from the NISE Net Forums formative evaluation database.

Investigation of Evaluation Reports

The first step of the analysis process was to review Years 1-5 NISE Net reports about SEI topics and products. Evaluators read 23 different NISE Net reports for this chapter. Five of these reports were NISE Net NSF annual reports. When reviewing these reports, evaluators focused on sections that described the number of SEI-related products produced and implemented by NISE Net partners each year. The other 18 reports were research and evaluation reports which included the following:

- Inverness Research Inc. report:
  - *Overview of the NISE Network Evaluation*
- Multimedia Research:
  - *Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Healthcare*
  - *Summative Evaluation of Awareness of Nanotechnology by the Museum Public*
- Museum of Science reports:
  - *NISE Net Public Impacts Summative Evaluation: Study 2*
  - *NISE Net Public Impacts Summative Evaluation: Study 3*
  - *"Energy Challenges, Nanotech Solutions" Forum Formative Evaluation Summary Report*
  - *"Nanomedicine in Healthcare" Forum Formative Evaluation Summary Report*
  - *"Privacy. Civil Liberties. Nanotechnology" Forum Formative Evaluation Summary Report*
  - *"Risks, Benefits, and Who Decides?" Forum Formative Evaluation Summary Report*
- Science Museum of Minnesota reports:
  - *2008 NanoDays Participating Organizations Evaluation*
  - *2010 Site Visit Evaluation Report*
  - *Exhibit and Program Summative Evaluation: Year 4 Progress Report*
  - *NISE Network Regional Workshops: Round One 2008 Formative Evaluation Report*
  - *NISE Network Regional Workshops: Second Round of Workshops Formative Evaluation*
  - *ASTC Forum Workshop Evaluation*
  - *NanoDays 2010 Poster Evaluation*
  - *Year 5 Summative Evaluation of Exhibits and Programs*

- Oregon Museum of Science and Industry report:
  - *2010 Delivery and Reach Study: NISE Network 2010 Summative Evaluation*

Additionally, the evaluators reviewed research and evaluation reports from other projects that incorporated SEI content into their informal science education products. Findings from these reports were compared to the findings about SEI products produced by NISE Net. The non-NISE Net reports reviewed as a part of this analysis included the following:

- *Energy Forum Summative Evaluation Report by Museum of Science,*
- *Forum in Review: Four Public Discussions on Science, Technology, and Society by Museum of Science,*
- *Green Fuel Summative Evaluation Report by Museum of Science,*
- *Public Engagement in Current Health Science at the Current Science & Technology Center, Museum of Science, Boston by Institute for Learning Innovation,*
- *Nanotechnology Onstage at the Museum of Science by Museum of Science,*
- *Reaching Out to New Audiences in Our Science, Technology and Society Discussion Programming by Museum of Science, and*
- *Visitor Preferences: Results from the Showcase Technology Survey by Museum of Science.*

After evaluators reviewed all of these reports, they summarized their findings and looked across reports for common conclusions. However, evaluators were not able to conduct any statistical analyses of these data. Therefore, these findings were used to triangulate and support findings that were discovered through the re-analysis of the NISE Net Forums formative evaluation database.

Re-analyze the NISE Net Forums formative evaluation database

Another step of the analysis was re-analyzing NISE Net evaluation data sources pertaining to SEI-related products in order to determine what impacts the products had on public audiences. Evaluators re-analyzed the NISE Net Forums formative evaluation database for this report chapter. This dataset contains 980 pre/post exit surveys collected during 34 NISE Net Forums over the first five years of the Network. The forums included in this dataset were collected at five different NISE Net subawardee institutions[28] and covered five different forum topics (Table 2).

[28] The five NISE Net Forums team institutions were the Exploratorium, Museum of Life and Science, Museum of Science, Oregon Museum of Science and Industry, and Science Museum of Minnesota.

Table 2. Number of events evaluated and number of surveys in the NISE Net Forums formative evaluation database split by forum topic.

Forum Topic[a]	Number of Events Evaluated	Number of Surveys Collected
Nanotechnology Regulation	13	428
Medicine	10	317
Energy	6	97
Privacy	3	63
Consumer Product Labeling	2	75
Total	34	980

a. The forum topics correspond to the following forums: nanotechnology regulation to "Risks, Benefits, and Who Decides?," medicine to "Nanotechnology in Healthcare," energy to "Energy Challenges, Nanotech Solutions?," privacy to "Privacy. Civil Liberties, Nanotechnology," and consumer product labeling to "Nanotechnology in Cambridge: What Do You Think?" and "Nanotechnology in Consumer Products."

Since the focus of the forums is societal and ethical implications of nanotechnology, the NISE Network Forums formative evaluation database was used as the primary source of data for this chapter. When data is cited throughout as part of the forums formative evaluation, it was derived from this database. In the analysis of this database evaluators split this data by forum topic in order to discover if there were differences in the audience makeup because of content. It was possible to conduct these analyses because visitors had to sign up for the NISE Net Forums ahead of time and make a conscious decision to attend these programs. Therefore, any differences observed are likely to relate to the topic of the forum or how the forum was marketed and not chance. Additionally, evaluators conducted analyses in order to understand what visitors learned from and valued about their forum experiences. Whenever comparative tests of significance were conducted, the level of significance was set at 0.05. Only statistically significant results are described in this report.

There are a number of limitations inherent to the NISE Net Forums formative evaluation database as it pertains to the SEI chapter of the Review. First, team members made iterative changes to the forums' content and formats throughout the formative evaluation process which likely impacted survey findings both within and across forum topics. Secondly, there were some differences in the way that team members recruited participants to their forums. However, analysis of the surveys reveals that 69% of the survey respondents (304 of 440) attended the museum who hosted the event within the previous year, indicating that they were frequent museum visitors. Therefore, it is unlikely that these different recruitment methods had a strong impact on the composition of the participants. Finally, the number of surveys collected about each of the forum topics was different. Because more surveys were collected at the forums about nanotechnology regulation (n=428) and medicine (n=317), forums about these topics had a greater impact on the cumulative findings about the NISE Net Forums formative evaluation database (Table 2). Such limitations were taken into consideration in the interpretation of the findings.

Findings & Discussion

Findings about the impact of societal and ethical implications content on the public include the following:

1. Participants learned about the societal and ethical implications of nanotechnology as well as nanoscale science, engineering, and technology from SEI-related products.
2. The forums gave participants a chance to practice and increase their comfort in participating in discussions about nanoscale science, engineering, and technology.
3. Different demographic groups were attracted to different forum topics.
4. SEI programming reached fewer members of the public than other NISE Net products during Years 1 – 5.
5. There is an opportunity for the NISE Net to expand SEI-related educational experiences in Years 6 – 10.

Finding 1: Participants learned about the societal and ethical implications of nanotechnology as well as nanoscale science, engineering, and technology from SEI-related products.

Looking at the evaluations of the different NISE Net products containing societal and ethical implications content, it was found that these products lead public participants to learn about a variety of topics. Additionally, it appears that the products may have the ability to encourage continued learning about and interest in nano. The main themes about what public participants learned from the SEI products are the following:

- Public participants learned about nanoscale science, engineering, and technology and its societal and ethical impacts from the forum programs.
- Public participants reported that non-forum SEI products were about nanoscale science, engineering, and technology, as well as societal and ethical implications content.
- Members of the public reported that some SEI products led them to continue to pay attention to nanoscale science, engineering, and technology after their participation.

Public participants learned about nanoscale science, engineering, and technology and its societal and ethical impacts from the forum programs.

According to both the NISE Net Forums formative evaluation database and the *Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Healthcare,* the public was able to learn both about nanoscale science, engineering, and technology as well as its societal and ethical implications through the forums (Flagg & Knight-Williams, 2008). However, while findings from the NISE Net Forums summative evaluation indicate that participants were able to make significant gains in both their knowledge and awareness of nanotechnology and its risks and benefits, findings from the NISE Net Forums formative evaluation database show that when participants self-report their learning they are more likely to report that they learned about nanoscale science, engineering, and technology than its societal and ethical implications.

As a part of the NISE Net Forums summative evaluation, evaluators asked participants questions to understand how the nanomedicine forum impacted their understandings. Findings from this evaluation indicate that the forum had statistically significant impacts on participants'

understandings of nanotechnology. For example, a Wilcoxin ranked signs[29] test indicated that participants gave a significantly higher ranking to the statement "I feel informed about nanotechnology"[30] after the forum (N=30, Z=3.9769, p<.0001). Additionally, the evaluation found that the forum significantly increased participants' understanding that nanotechnology operates on a submicroscopic or smaller scale (McNemar test with continuity correction: N=32, X^2=4.923, df=1, p=.0265), and that nanotechnology properties are dependent on size or scale (McNemar test with continuity correction: N=32, X^2=4.900, df=1, p=.0269) (Flagg & Knight-Williams, 2008).

NISE Net Forums summative evaluation findings also indicate that the nanomedicine forum significantly increased participants' awareness of the societal and ethical implications of nanotechnology. Before and after the forum, participants were asked to rank their awareness of the benefits and risks of nanotechnology. Wilcoxin ranked signs tests indicated that participants felt significantly more aware of the benefits or potential benefits of nanotechnology in personal care products like lotions and cosmetics (N=30, Z=3.5712, p=.0002) and medicine (N=30, Z=0.1198, p=.0009) after the forum. Wilcoxin ranked signs tests also indicated that participants felt significantly more aware of the risks or potential risks of nanotechnology personal care products (N=29, Z=3.9668, p<.0001) and medicine (N=30, Z=3.7233, p<.0001) after the forum (Flagg & Knight-Williams, 2008).

As a part of the NISE Net Forums formative evaluation, public participants were asked to describe what they learned from the forum that they did not know before. When looking across the forum formative surveys, it was found that the results from this question support the findings from the NISE Net Forums summative evaluation in that they indicate that participants felt they learned about both SEI and nano content from the forums. Of the 621 question responses, participants most commonly reported that they learned about nanoscale science, engineering, and technology topics such as "uses of nanotechnology" (157 of 621, 25%) or "science/technology of nano" (154 of 621, 25%) from the forums. Fewer participants said they learned about SEI topics such as "societal aspects of nanotechnology" (74 of 621, 12%) or "risks of nanotechnology" (60 of 621, 10%) (Table 3).

[29] The Wilcoxin ranked signs test is a non-parametric statistical test that can be used to assess whether there are differences between paired variables in a single sample population. This test can be used in place of a Student's t-test if the sample population cannot be assumed to be normally distributed or the data is ordinal.

[30] Participants were asked to rank the statement on a scale of 1 to 7 where 1 is "strongly disagree" and 7 is "strongly agree."

Table 3. Visitor Responses to the NISE Net Forums formative evaluation open-ended pre/post exit survey question: "What, if anything, did you learn from the forum that you didn't know before?" (N=899)[31]

	Number of Survey Respondents	Percent of Survey Respondents	Example Quotes
No answer	278	31%	--
Uses of nanotechnology	157	17%	"That nanoparticles are in my sunscreen." (Explo 2.2 Survey #14)
About science/ technology of nano	154	17%	"I learned about the exact size of a nanometer…" (OMSI 3.1 Survey #4)
Societal aspects of nano	74	8%	"I haven't thought much about the ethics side of new technology…" (MLS 2.3 Survey #30)
About the risks of nano	60	7%	"How amazing nano tech can be - both negative and positive" (MOS 5.1 Survey #7)
Lots of information	50	6%	"Dr. Shankar gave a lot of new information…" (OMSI 3.1 Survey #5)
Significance of nanotechnology	45	5%	"the scope of nanotechnology" (Explo 2.1 Survey #30)
What others are thinking	45	5%	"I was surprised how similarly many people think." (SMM 3.1 Survey #4)
Other	41	5%	"...web page of consumer products…" (SMM 2.1 Survey #13)
Regulations and policies of nanotechnology	39	4%	"... The need to democratize scenarios as in Ontario energy policy." (Explo 3.4 Survey #1)
About the complexity of the issue	20	2%	"This subject is harder to talk about than I expected." (MLS 2.3 Survey #31)
About civic discourse/public involvement	12	1%	"...Very impressed with the outreach to the community -- a model for other towns." (MOS 3.3 Survey #16)
Advancement in science and technology	11	1%	"How rapid advance is headed." (SMM 3.1 Survey #1)
Future directions of nano	10	1%	"...what all is possible…" (ASTC 3.1 Survey #19)
Nothing	9	1%	"Nothing." (OMSI 3.1 Survey #18)
Funding of nanotechnology	8	1%	"The amount of money going towards nanotech in N.C." (MLS 2.1 Survey #16)
Very little	7	1%	"Not too much, but that's okay. It was still an interesting evening." (OMSI 2.1 Survey #25)
That I didn't know much about nano before	6	1%	"Didn't know about nano." (Explo 3.4 Survey #18)

[31] The total number of survey respondents is greater than 899 because some question responses fit into more than one code.

About current research	6	1%	"About nano research." (MLS 2.3 Survey #25)
About alternative energy or conservation	6	1%	"Range of ideas relating nanotech to Alt. Energy" (MOS 3.1 Survey #7)
About the benefits of nano	4	0%	"Potential benefits...of nanotech." (MOS 3.2 Survey #1)
Places nanotechnology is researched	3	0%	"...centers for nano-biotechnology, and companies associated with nano-biotechnology." (MLS 2.1 Survey #5)
About the researchers who presented	2	0%	"That MIT's institute for researching military nanotech is named the Institute for Social Nanotechnology." (SMM 1.1 Survey #28)
About nanotechnology programs for the public	2	0%	"People are trying to share info @ NANO to make the topic more interesting and accessible." (MLS 2.3 Survey #21)
Misconceptions from the media	2	0%	"...media leads me to believe that nanotechnology is all man-made." (OMSI 2.1 Survey #21)
Not enough information to make a decision	2	0%	"Don't have enough info to determine if I am pro or con." (MOS 2.2 Survey #13)
The plural of Forum	2	0%	"... The plural of forum!" (OMSI 2.1 Survey #9)
What issues I need to consider about nano	2	0%	"I got a better sense of what I need to think about when I consider nanotechnology issues." (SMM 3.4 Survey #18)

On the formative evaluation pre/post exit surveys, public participants were also asked to report their pre-forum knowledge of nanotechnology and the forum topic as well as whether they felt more informed about these topics after the programs. The findings indicate that many participants did not feel they had a strong understanding of either the SEI topic or nanotechnology prior to the forum. However, they did feel that their baseline understanding of the SEI topic was greater than their understanding of nanotechnology. Of the 609 participants who ranked both of the pre-forum knowledge statements, over half (58%) "agreed" or "strongly agreed" with the statement "I have a strong understanding of [the SEI topic][32]" while less than a third of the participants (32%) "agreed" or "strongly agreed" with the statement "I have a strong understanding of nanotechnology" (Table 4). Comparing individuals' rankings of these two statements through a Wilcoxin signed ranks test, it was found that there was a significant difference in participants' rankings of the two statements with participants giving a higher ranking to their understanding of the SEI topic ($N=609$, $Z=-10.723$, $p<.001$).

[32] The topic visitors were asked about differed based on forum topic ("Who decides": relationship between technology and society, relationship between technology and the environment; "Energy": energy technologies; "Privacy": privacy issues; "Consumer product labeling": consumer product regulation).

Table 4. NISE Net Forums formative evaluation participants' ratings of statements about their level of understanding of nanotechnology and SEI-related topics prior to the forums.[33]

	N	Mean	SD	Percent of Respondents Who "Agree" or "Strongly Agree"
I have a strong understanding of nanotechnology.	609	2.2	0.8	32%
I have a strong understanding of [the SEI topic].[a]	609	2.6	0.8	58%

a. The topic visitors were asked about differed based on forum topic ("Who decides": relationship between technology and society, relationship between technology and the environment; "Energy": energy technologies; "Privacy": privacy issues; "Consumer product labeling": consumer product regulation).

After the forums, participants were asked to rank their agreement with statements about whether they felt more informed about nanotechnology, the SEI topic of the forum, and the risks and benefits of the SEI topic. The results indicate that participants felt they learned more about nanotechnology than SEI-related topics such as risks and benefits from the forum. Over three quarters of the participants "agreed" or "strongly agreed" with the statements "I feel more informed about nanotechnology" (90%), " I feel more informed about [the SEI topic][34]" (81%), and "I feel more informed about the risks and benefits of [the SEI topic][35]" (78%) (Table 5). When comparing individuals' rankings of the statement about nanotechnology to the statement about the SEI topic through a Wilcoxin signed ranks test, it was found that there was a significant difference between forum participants rankings of the two statements with a higher ranking being given to the statement about feeling more informed about nanotechnology after the forum ($N=551$, $Z=-6.038$, $p<.001$). When comparing individuals' rankings of the statement about nanotechnology to the statement about the risks and benefits of the SEI topic through a Wilcoxin signed ranks test, it was found that there was again a statistically significant difference in the rankings given by forum participants with a higher ranking being given to the statement about feeling more informed about nanotechnology after the forum ($N=466$, $Z=-7.242$, $p<.001$). It is unknown whether this difference was found because participants felt they already had a strong baseline understanding of the SEI-related topics before the forum and so they did not learn as much about it through the program as they learned about nano, if participants felt they had the most to learn about nano and so reported the greatest gains in regards to this topic, if participants were just more likely to equate hearing about nano content with learning rather than hearing about SEI-related content, or if participants did learn more about nano than SEI through participation in forums. It should be noted that despite the statistical differences seen in reported learning of these topics that most visitors either "agreed" or "strongly agreed" that they felt more informed about all of these topics after the forums.

[33] Forum participants were asked to rank these statements on a scale of 1 to 4 where 1 is "strongly disagree," 2 is "disagree," 3 is "agree," and 4 is "strongly agree." In the tables, "N" is the number of question respondents, "M" stands for mean, and "SD" stands for standard deviation.

[34] The topic visitors were asked about differed based on forum topic ("Energy": energy technologies; "Privacy": privacy issues; "Consumer product labeling": consumer product regulation).

[35] The topic visitors were asked about differed based on forum topic ("Energy": nanotechnology-dependent energy; "Privacy": nanotechnology-based tracking devices; "Consumer product labeling": nanotechnology).

Table 5. NISE Net Forums formative evaluation participants' rankings of statements about whether they felt more informed about nanoscale science, engineering, and technology and SEI content after the forums.[36]

	N	Mean	SD	Percent of Respondents Who "Agree" or "Strongly Agree"
I feel more informed about nanotechnology.	551	3.3	0.7	90%
I feel more informed about [the SEI topic].[a]	551	3.1	0.7	81%
I feel more informed about the risks and benefits of [the SEI topic].[b]	466	3.0	0.7	78%

a. The topic visitors were asked about differed based on forum topic ("Energy": energy technologies; "Privacy": privacy issues; "Consumer product labeling": consumer product regulation). b. The topic visitors were asked about differed based on forum topic ("Energy": nanotechnology-dependent energy; "Privacy": nanotechnology-based tracking devices; "Consumer product labeling": nanotechnology).

Public participants reported that non-forum SEI products were about nanoscale science, engineering, and technology, as well as societal and ethical implications content.

Looking at evaluations of non-forum NISE Net products containing societal and ethical implications content, it was discovered that members of the public report that these products contain both nano and SEI content. However, the percent of participants who report that the products contain SEI content varies quite a bit. It is possible that the difference in the proportion of visitors who reported the products covered SEI topics is a result of the differing amounts and treatment of SEI content contained in each of the products as those products that had a stronger focus on SEI also had more participants discussing this content.

The *Exhibit & Program Summative Evaluation Year 4 Progress Report* describes preliminary results from the summative evaluation of select exhibits and programs. Two of the programs discussed within the report – "Wheel of the Future" and "Nano Dreams and Nano Nightmares" – contained SEI content. According to the report, more people felt the main message of the "Wheel of the Future" program was the field of nanotechnology and applications (43%) than the societal impacts of nanotechnology (23%) (Table 6) (Ellenbogen, et al., 2009). Even fewer members of the public felt that a main message of the "Nano Dreams and Nano Nightmares" program was nanotechnology's societal and ethical impacts. For this program, 4% of the survey respondents reported that a main message of the programs was societal impacts of nanotechnology. More participants thought a main message was nanoscale and things measured in it (48%), field of nanoscience and research (25%), behavior of particles or molecules (18%), field of nanotechnology and applications (18%), or provided a description of their museum experience (6%) (Table 7) (Ellenbogen, et al., 2009).

[36] Forum participants were asked to rank these statements on a scale of 1 to 4 where 1 is "strongly disagree," 2 is "disagree," 3 is "agree," and 4 is "strongly agree."

Table 6. Visitor responses to the "Wheel of the Future" Year 4 exhibit & program summative evaluation survey open-ended question: "In your own words, what would you say the program was trying to show visitors?" (N=161).[37]

	Percent of Survey Respondents
Field of nanotechnology and applications	43%
Field of nanoscience and research	23%
Societal impacts	23%
Description of museum experience	15%
Nanoscale and things measured in it	4%
Behavior of particles or molecules	1%
Things behave differently when they are small	1%
Other	4%

Note. Reprinted from "Exhibit & Program Summative Evaluation – Year 4 Progress Report," by K. Ellenbogen, S. Cohn, and A. Onkka, 2009.

Table 7. Visitor responses to the "Nano Dreams and Nano Nightmares" Year 4 exhibit & program summative evaluation survey open-ended question: "In your own words, what would you say the program was trying to show visitors?" (N=125)[38].

	Percent of Survey Respondents
Nanoscale and things measured in it	48%
Field of nanoscience and research	25%
Behavior of particles or molecules	18%
Field of nanotechnology and applications	18%
Description of museum experience	6%
Societal impacts	4%
Other	5%

Note. Reprinted from "Exhibit & Program Summative Evaluation – Year 4 Progress Report," by K. Ellenbogen, S. Cohn, and A. Onkka, 2009.

Similar results were discovered when looking at the NISE Net exhibits. As a part of the Year 5 summative evaluation of the NISE Net exhibition, visitors were asked to describe its main messages. As before, most visitors reported that the main message of the product had to do with nano content. In this case, the most common messages described by visitors were that the exhibition was about "technology" (40.0% of Museum of Science (MOS) participants, 22.7% of Little Rock participants, and 10.0% of OMSI participants), everyday applications of nano (36.4% of MOS participants, 19.7% of Little Rock participants, and 43.3% of OMSI participants), and

[37] The total percentage is greater than 100% because some participant responses fell into more than one coding category.
[38] The total percentage is greater than 100% because some participant responses fell into more than one coding category.

medical applications of nano (38.2% of MOS participants, 21.2% of Little Rock participants, and 35.0% of OMSI participants). Many fewer participants reported that the exhibition was about risks and benefits of nano (7.3% of MOS participants, 0% of the Little Rock participants, and 5% of the OMSI participants) (Table 8) (Bequette, et al., 2011).

Table 8. Visitor responses to the *Year 5 Summative Evaluation of Exhibits and Programs* survey open-ended question: "In your own words, what would you say the exhibit was trying to show visitors?"[39].

	Post-exhibit Boston, MOS (n=55)	Post-exhibit Little Rock, MOD (n=66)	Post-exhibit Portland, OMSI (n=60)
Nano means small	7.3%	7.6%	8.3%
"Technology"	40.0%	22.7%	10.0%
Everyday applications of nano	36.4%	19.7%	43.3%
Medical applications of nano	38.2%	21.2%	35.0%
New research/future work	18.2%	6.1%	15.0%
Risks and benefits of nano	7.3%	0.0%	5.0%
Other	12.7%	6.1%	21.7%

Note. Reprinted from "Year 5 Summative Evaluation of Exhibits and Programs," by M. Bequette, G. Svarovsky, and K. Ellenbogen, 2011.

An evaluation was also conducted on the NanoDays SEI posters. The posters described the risks and benefits of particular nanotechnology-based products such as sunscreen, water filters, and antibacterial stuffed animals and were meant to accompany NanoDays programs. As a part of the evaluation, visitors were asked to report what they thought to be the main messages of the posters. This evaluation found that just under one-third of visitors felt that a main message of the posters was general information about technology (31%, 9 of 30) or the benefits and risks of nanotechnology (30%, 9 of 30). Just under one-quarter of visitors felt that the main message of the posters was benefits of nanotechnology only (22%, 7 of 30), and fewer people said a main message of the posters was risks of nanotechnology only (17%, 5 of 30) (Cohn & Onkka, 2010).

Members of the public reported that some SEI products led them to continue to pay attention to nanoscale science, engineering, and technology after their participation.

Evaluations of some of the societal and ethical implications products indicate that it is possible that societal and ethical implications products can spur participants to continue to learn about, discuss, or take action in regards to nanotechnology. These findings indicate that SEI products have the potential to increase visitors' interest and engagement in nanoscale science, engineering, and technology beyond their museum experience.

As a part of the NISE Net Forums summative evaluation, a sub-set of the participants took part in a follow-up survey two weeks after the forum. As a part of this survey, participants were asked about nanotechnology-related activities they experienced after the forum. Over three-quarters of the follow-up survey respondents (76%, 13 of 17) indicated that their forum participation led

[39] The total percentage is greater than 100% because some participant responses fell into more than one coding category.

them to pay more attention to nanotechnology references in print, TV, or radio. Additionally, over half of the follow-up survey respondents reported that the forum led them to discuss the benefits of nanotechnology with others (71%, 12 of 17), discuss the risks of nanotechnology with others (65%, 11 of 17), explain what nanotechnology is to others (65%, 11 of 17), or search for more general information about nanotechnology (53%, 9 of 11) (Table 9) (Flagg & Knight-Williams, 2008).

Table 9. Activities that NISE Net Forums summative evaluation participants reported they participated in after the program (n=17).

	Number of Follow-up Participants	Percent of Follow-up Participants
Paid more attention to references to nanotechnology in print, TV, or radio	13	76%
Discussed with others the benefits of nanotechnology	12	71%
Explained what nanotechnology is to others	11	65%
Discussed with others the risks of nanotechnology	11	65%
Searched for more information about nanotechnology generally	9	53%
Searched for more information about nanotechnology in personal care products	5	29%
Searched for more information about nanotechnology in medicine	5	29%
Looked at nano-related product labeling	2	12%
Purchased nano-related products	2	12%

Note. Reprinted from "Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Healthcare," by B. Flagg and V. Knight-Williams, 2008.

These results are supported by the follow-up study conducted as a part of the NISE Net Year 1 Forums formative evaluation. Participants from three of the Museum of Science forums and two of the Museum of Life and Science forums were asked to complete a phone interview or an email survey within three months after their forum experience. According to the results of this study, over three-quarters of the respondents (88%, 38 of 43) talked with someone about their forum experience. These participants discussed what they thought of the forum, described nanotechnology to others, and sometimes described its risks and benefits. Additionally, 40% of the respondents (17 of 43) reported they took steps to follow-up on their forum learning. The kinds of things that these participants said they did included paying more attention to nanotechnology in print, TV, or radio, looking for nanotechnology in products, and joining nanotechnology-related organizations.

As a part of the NanoDays poster evaluation, public participants were also asked an open-ended question to understand what kinds of actions they felt they might take in response to posters created about the societal and ethical implication of nanotechnology by NISE Net. The posters were created in Year 5 to provide SEI content that could go alongside activities and exhibits presented as a part of NanoDays. They covered various content including the risks and benefits of nanotechnology-based products such as antibacterial stuffed animals, sunscreen, and water filters. After public participants looked at the posters, they were asked to take part in an interview. During the interview, participants were asked about their interest in acting in response to the posters. Almost two-thirds of the participants (63%) said the posters or handouts (which also contained the poster content) interested them in thinking about, talking

about, or taking an action related to nanotechnology. Of these participants, almost three-quarters (74%) said the posters made them want to think or reflect about the content. Other participants said that the posters interested them in taking an action such as finding out more information about nanotechnology through the Internet (32%), or in talking to others about nanotechnology (18%) (Cohn & Onkka, 2010).

Finding 2: The forums gave participants a chance to practice and increase their comfort in participating in discussions about nanoscale science, engineering, and technology.

During the forum evaluations, public participants were asked not only about their learning but also about how they felt about taking part in discussions about the societal and ethical implications of nanotechnology. The main themes related to participants' feelings about their discussions were the following:

- Participants felt the forums allowed them to share their opinions about nanoscale science, engineering, and technology in a comfortable setting.
- Participants felt the forums allowed them to weigh the pros and cons of nanoscale science, engineering, and technology within a group of diverse individuals.

Participants felt the forums allowed them to share their opinions about nanoscale science, engineering, and technology in a comfortable setting.

Analyses of the NISE Net Forums formative evaluation database and the NISE Net Forums summative evaluation indicate that the public participants felt confident in their ability to express their opinions about science and technology topics before they participated in the forums. Feeling confident about their skills at the outset, the forum programs appeared to boost their confidence even further. Additionally, it appeared that the forums provided an atmosphere where almost all the public participants got the chance to express their viewpoints.

During the NISE Net Forums formative evaluation, public participants were asked to rank a series of statements about their comfort expressing opinions about certain topics before as well as during the forums. Before the forums, less than three-quarters of the public participants "agreed" or "strongly agreed" with the statements "I feel comfortable expressing my opinions about nanotechnology" (59%) and "I feel comfortable expressing my opinions about [the SEI topic][40]" (68%) (Table 10). Comparing individuals' rankings of the two statements, a Wilcoxin ranked signs test showed that participants gave a significantly higher ranking to feeling comfortable expressing their opinions about the SEI topic than nanotechnology before the forums (N=225, Z=-3.022, p=.003). These findings indicate that while most of the public participants feel comfortable expressing their opinions about either nanotechnology or SEI topics before the forums, they feel more confident in their ability to express their viewpoints about the SEI topics.

[40] The topic visitors were asked about differed based on forum topic ("Energy": nanotechnology-dependent energy; "Privacy": nanotechnology-based tracking devices; "Consumer product labeling": nanotechnology).

Table 10. NISE Net Forums formative evaluation participants' rankings of statements about comfort and opportunity to express their opinions.[41]

	N	Mean	SD	Percent of Respondents Who "Agree" or "Strongly Agree"
I feel comfortable expressing my opinions about nanotechnology.	225	2.6	0.8	59%
I feel comfortable expressing my opinions about [the SEI topic].[a]	225	2.7	0.8	68%
I had a chance to voice my opinions about the topic.	196	3.5	0.5	98%
I felt comfortable voicing my opinions.	680	3.4	0.6	95%

a. The topic visitors were asked about differed based on forum topic ("Energy": nanotechnology-dependent energy; "Privacy": nanotechnology-based tracking devices; "Consumer product labeling": nanotechnology).

After the forums, public participants, who took part in both the NISE Net Forums formative and summative evaluations, were asked about their experience expressing their opinions. The forum formative evaluation found that almost all of the 196 participants (98%) who ranked the statement "I had a chance to voice my opinions about the topic" either "agreed" or "strongly agreed." Additionally, most of the 680 public participants (95%) who ranked the statement "I felt comfortable voicing my opinions" either "agreed" or "strongly agreed" (Table 10). As a part of the NISE Net Forums summative evaluation participants were asked to rank a series of statements both before and after the forums about opportunities to express their opinions during the programs as well as their comfort. On average, participants agreed with the statement "I added my own viewpoints to the group discussion" (N=32, M=6.0).[42] Participants were also asked to rank the statement "I feel comfortable expressing my viewpoints about nanotechnology in a group discussion" both before and after their forum experience. A Wilcoxin ranked signs test found that participants ranked the statement significantly higher after the forum (N=29, Z=2.5249, p=.0058) (Flagg & Knight-Williams, 2008). These findings indicate that the forum participants feel that the program provides them with a comfortable atmosphere where they have the opportunity to express their opinions and feel comfortable doing so.

Participants felt the forums allowed them to weigh the pros and cons of nanotechnology within a group of diverse individuals.

Analyses of the NISE Net Forums formative evaluation database and NISE Net Forums summative evaluation show that participation in the forum provided the public with the chance to diversify the number of viewpoints about nanotechnology that they were familiar with. Additionally, the findings indicate that the forums provided participants with a chance to consider both the positive and negative aspects of nanotechnology.

After the forums that were conducted as part of the formative evaluation, public participants were asked a series of questions to gauge the quality of the small group discussion. Of the 535 public participants who ranked the statement "A diverse range of viewpoints were represented

[41] Forum participants were asked to rank these statements on a scale of 1 to 4 where 1 is "strongly disagree," 2 is "disagree," 3 is "agree," and 4 is "strongly agree."
[42] Public participants were asked to rank their agreement with the statement on a scale of 1 "strongly disagree" to 7 "strongly agree."

in our small group discussion," almost all of them (86%) either "agreed" or "strongly agreed." Additionally, almost all of the 499 public participants (91%) who ranked the statement "We weighed the pros and cons of the [forum topic][43] during our small group discussion" either "agreed" or "strongly agreed" (Table 11).

Table 11. NISE Net Forums formative evaluation participants' rankings of statements about the diversity of viewpoints and considerations of both pros and cons during the small group discussion.[44]

	N	Mean	SD	Percent of Respondents Who "Agree" or "Strongly Agree"
A diverse range of viewpoints were represented in our small group discussion.	535	3.1	0.7	86%
We weighed the pros and cons of the [forum topic][a] during our small group discussion.	499	3.2	0.6	91%

a. The topic visitors were asked about differed based on forum topic ("Who decides": different stakeholders' roles during our discussion; "Nanomedicine": medical nanotechnologies; "Energy": nanotechnology-dependent energy; "Privacy": nanotechnology-based tracking devices, nanotechnology; "Consumer product labeling": regulation options for products containing nanomaterials).

When participants were asked to rank a series of statements similar to these as a part of the NISE Net Forums summative evaluation, similar results were found.[45] The average ranking for the statement "I was exposed to viewpoints different from my own" was slightly below "agree" (N=32, M=5.7). The average ranking for the statement "Our discussions effectively considered risks or potential risks of nanotechnology" was slightly above agree (N=32, M=6.2). Finally, the average ranking for the statement "Our discussions effectively considered benefits or potential benefits of nanotechnology" was "agree" (N=32, M=6.0) (Flagg & Knight-Williams, 2008).

Finding 3: Different demographic groups were attracted to different forum topics.

Previous studies have shown that the topic that is explored as part of an exhibit or program can have an impact on who is attracted to use that product (Chin & Reich, 2007; Chin, Reich, & Kollmann, Forthcoming). Therefore, evaluators were interested to know if differences would be seen in the demographics of individuals who attended different forums. Comparing the participants who used the forum products, it was discovered that there were differences in the demographics of visitors who attended the different NISE Net forums based on their topic. These differences were seen in the sexes, ages, and races/ethnicities of participants. The main themes about those demographics were the following:

[43] The topic visitors were asked about differed based on forum topic ("Who decides": different stakeholders' roles during our discussion; "Nanomedicine": medical nanotechnologies; "Energy": nanotechnology-dependent energy; "Privacy": nanotechnology-based tracking devices, nanotechnology; "Consumer product labeling": regulation options for products containing nanomaterials).
[44] Forum participants were asked to rank these statements on a scale of 1 to 4 where 1 is "strongly disagree," 2 is "disagree," 3 is "agree," and 4 is "strongly agree."
[45] Public participants were asked to rank their agreement with the statement on a scale of 1 "strongly disagree" to 7 "strongly agree."

- More males were attracted to forums about energy than females.
- Forum topics such as energy and consumer product labeling were more attractive to older adults.
- Members of the public who were not white appeared to be more attracted to forums about applied topics such as medicine.

More males were attracted to forums about energy than females.

One difference was discovered in the sex of participants who attended NISE Net forums about varying topics. Of the 944 visitors who answered a question about their sex on forum formative evaluation surveys, it was discovered that attendees were split almost evenly between males (51%) and females (49%). However, when splitting this data based on the topic of the forum, it was found that there was a significant difference in the distribution of males and females ($N=944$, $X^2=17.390$, $df=4$, $p=.002$)[46] with more males attending the energy forums than expected (Table 12). Because educators did not try to recruit individuals of a specific sex to the forums, these findings imply that there may be something about the forum topic that attracted more males to the energy forums.

Table 12. Number and percent of males and females who attended the different forums.

Forum Topic	Number of Males	Percent Male	Number of Females	Percent Female	Total
Nanotechnology Regulation	227	55%	188	45%	415
Medicine	138	45%	168	55%	306
Energy	60	65%	33	35%	93
Privacy	26	44%	33	56%	59
Consumer Product Labeling	29	41%	42	59%	71
Total	480	51%	464	49%	944

This finding is supported by a series of MOS evaluation reports about energy-related products and topics. A report about MOS visitor preferences for technology topics reported that males were more interested in discussing the topic of green energies than females (Chin & Reich, 2005). According to a summative evaluation report about a previous non-NISE Net Museum of Science energy forum, most of the attendees were male (approximately 57% male and 43% female) (Boyce, 2005a). Finally, an evaluation of a Museum of Science green fuel exhibit found that many more males (58%) used the exhibit than females (42%) (Boyce, 2005b).

[46] X^2 stands for chi-square test. A chi-square test is a non-parametric statistical test. For this report, chi-square tests for homogeneity were used to assess whether there were any differences in the observed distributions of multiple groups.

Forum topics such as energy and consumer product labeling were more attractive to older adults.

Analysis of the NISE Net Forums formative evaluation database also indicates that there are differences in the ages of visitors who attended different forums. The forum program was created for adults and teens, but marketing for this program generally focused on adults. For this reason, very few participants were under the age of 18, and it was not possible to include children under 18 in the statistical sample. However, it was possible to look at the age distributions of the adult forum participants. Looking across the ages of all the forum participants, it was found that similar proportions of participants were in all of the age categories except 65+. Fewer participants fell into this age category. Analysis of the age data based on forum topic showed that there was a statistically significant difference in the age distributions of the adult attendees to the forums ($N=513$, $X^2=40.336$, $df=15$, $p<.001$). Differences from expected numbers were seen in the following topics and age categories (Table 13):

- Energy: fewer participants of ages 18-24 and more who were 65 years of age and older;
- Privacy: more participants between the ages of 18-24;
- Consumer product labeling: fewer participants of ages 18-24 and more 35-44 years of age.

Because forum recruitment did not target adults of specific ages except in the case of the privacy forums,[47] these findings indicate that there may be something about the topics of the forums that attracted adults of different ages to the programs. The topic of privacy may be more attractive to young adults, the topic of consumer product labeling may be more attractive to middle aged adults, and the topic of energy may be more attractive to older adults.

Table 13. Number and percent of attendees in different age categories who attended forums of different topics.

Forum Topic[a]	18-24	25-34	35-44	45-54	55-64	65+	Total
Medicine	62 (21%)	58 (20%)	44 (15%)	53 (18%)	59 (20%)	19 (6%)	295
Energy	8 (9%)	20 (22%)	17 (19%)	15 (17%)	14 (16%)	16 (18%)	90
Privacy	16 (29%)	11 (20%)	9 (16%)	13 (23%)	5 (9%)	2 (4%)	56
Consumer Product Labeling	6 (8%)	13 (18%)	20 (28%)	15 (21%)	7 (10%)	11 (15%)	72
Total	92 (18%)	102 (20%)	90 (18%)	96 (19%)	85 (17%)	48 (9%)	513

a. Age data was not collected on the surveys for the nanotechnology regulation forums.

[47] Recruitment and marketing for "Privacy" was unusual: SMM 3.4 participants were volunteers and speaker's students, ASTC 3.1 participants were ASTC Annual Meeting participants, and MOS 5.1 was held off-site and bilingual.

Members of the public who were not white appeared to be more attracted to forum programs about applied topics such as medicine.

Finally, differences were seen in the races and ethnicities of participants based on the different topics of the forums. Overall, many more people who only identified themselves as white (79%) attended the forums than people who identified themselves as non-white[48] (21%). However, an analysis of the forum formative data indicates that there was a significant difference in the distribution of whites and non-whites attending the programs based on topic (N=937, X^2=10.819, df=4, p=.029). The medicine forums were attended by more non-whites than expected, and the nanotechnology regulation forums were attended by fewer non-whites than expected (Table 14). However, overall, non-whites were in the minority at all of the forum types.

Table 14. Number and percent of white and non-white participants who attended the different forums.

Forum Topic	Number of Whites	Percent White	Number of Non-whites	Percent Non-white	Total
Nanotechnology Regulation	335	83%	71	17%	406
Medicine	221	72%	84	28%	305
Energy	75	80%	19	20%	94
Privacy	46	78%	13	22%	59
Consumer Product Labeling	59	81%	14	19%	73
Total	736	79%	201	21%	937

These findings are supported by the results of the NISE Net Forums summative evaluation which found that nearly three-quarters of the attendees (24 of 32, 74%) were white (Flagg & Knight-Williams, 2008). They also appear to agree with the findings of the non-NISE Net report *Reaching Out to New Audiences in Our Science, Technology and Society Discussion Programming*, which found that minority and low income individuals were more interested in programs covering practical topics or more basic information (such as health and wellness) while white and higher income individuals were more desirous of programs that covered controversial topics and had big name speakers (Chin & Reich, 2007).

[48] People were placed in the category of non-white if they identified themselves as a race/ethnicity other than white or who said they were both white and another race/ethnicity.

Finding 4: SEI programming reached fewer members of the public than other NISE Net products during Years 1-5.

Looking across multiple data sources, it was discovered that the SEI-related products did not reach as many members of the public as other NISE Net products during Years 1 – 5. There are a few reasons why SEI products did not have a broad impact on the public including the following:

- Few NISE Net products had SEI-related goals.
- Few institutions used the SEI products.
- Not as many members of the public interacted with SEI-related products as non-SEI products.

Few NISE Net products had SEI-related goals.

During the first five years of NISE Net, few products included societal and ethical implications content. As stated in the introduction to this chapter, NISE Net created 78 products that were included in the online catalog of products (www.nisenet.org/catalog) by the end of Year 5. Of these 78 products intended for implementation with a public audience, only 18 (23%) contained SEI content. The formats of these 18 products included media, exhibits, and programs. However, programs were most likely to contain this content (27%) (Table 1). Programs that contained SEI content included forums or science cafes (4 of 4, 100%), stage presentations (7 of 11, 64%), museum theater (1 of 2, 50%), classroom programs (1 of 3, 33%), cart demos (3 of 29, 10%), and facilitated activities (1 of 23, 4%).

When looking at the content knowledge areas that were covered as a part of these 78 products, it was discovered that SEI-related content knowledge was the least common. Two of the content knowledge areas, small and different (73%) and new applications (53%), were a part of over half of the NISE Net products. Manipulating matter was also covered in nearly half (43%) of the Year 1-5 products. However, the content knowledge area related to SEI – risks and benefits – was the least likely (22%) to be covered in NISE Net Year 1-5 products (Table 15).

Table 15. Content knowledge areas covered by the NISE Net-created products that were included in the nisenet.org catalog at the end of Year 5 (N=78).[49]

Content Knowledge	Number of Programs[a]	Number of Exhibits	Number of Media	Total Number of Products	Total Percent of Products
Small and different	35	8	14	57	73%
New applications	28	7	6	41	53%
Manipulating matter	20	5	7	32	41%
Risks and benefits	14	1	2	17	22%

a. Forums are included in the program category.

[49] The number of products listed in the table is greater than 78 because some products covered more than one content knowledge area.

Few institutions were using SEI-related products.

In addition to producing only a few SEI products in Years 1-5, it was also found that NISE Net institutions were not very likely to use the products connected to SEI goals during this time period. The *NISE Net Public Impacts Summative Evaluation: Study 2* reported that there were 2,143 implementations of exhibits and programs by Tier 1 and 2 institutions during 2009. Of the format types listed in this report, forums, stage presentations, and science theater are most likely to contain SEI content. However, of the 2,143 implementations, these formats only accounted for 26% of the 2009 Tier 1 and 2 nano-related implementations (Table 16) (Reich & Goss, 2009a).

Table 16. Formats of nano experiences delivered by Tier 1 and 2 reporting institutions.

	Number of Tier 1 Implementations	Number of Tier 2 Implementations	Total Number of Tier 1 and 2 Implementations
Cart demonstration	171	929	1,100
Stage presentation	292	150	442
Exhibit (days)	91	201	292
Other	27	168	195
Science theater	101	4	105
Forum	6	3	9

Note. Reprinted from "Public Impacts Summative Evaluation: Study 2," by C. Reich and J. Goss, 2009a.

Additionally, a survey of Tier 3 partners included in the *NISE Net Public Impacts Summative Evaluation: Study 2* suggests that the most commonly implemented programs were those that were not as likely to include societal and ethical implications content such as classroom activities (76 of 132 implementations, 58%) and cart demonstrations or programs (60 of 132, 45%). Less than a quarter of the Tier 3 organizations reported that they implemented programs that were more likely to contain SEI content such as forums (27 implementations, 20%) and museum theater (11, 8%) (Reich & Goss, 2009a).

Similar findings were also seen in 2010. According to the *2010 Reach and Delivery Study*, less than 10% of the NanoDays institutional participants used products that focused on societal and ethical implications such as forums (8%), the Decide game (8%), and science cafes (3%) (Pattison, et al., 2011). Additionally, this study reported that 99% of the institutions included as a part of the study had never done a forum (Pattison, et al., 2011). These findings show that even in Year 5 as the NISE Net had expanded to hundreds of institutions, only a small percentage of these institutions implemented NISE Net SEI products.

Not as many members of the public interacted with SEI-related products as non-SEI products.

The *2010 Delivery and Reach Study* indicates not only that few institutions implemented SEI-related NISE Net products in Year 5, but also that few visitors interacted with these products. As a part of this report, a study was conducted to estimate the number of visitors who encountered different types of NISE Net products during NanoDays. To do this, a subset of the NanoDays participant organizations was asked to count the number of visitors who experienced nano-related exhibits and programs. These numbers were then extrapolated to estimate the number of all NanoDays visitors who experienced different kinds of products. According the report, there

were an estimated 435,408 public participant encounters with nano-related products during NanoDays. If only NISE Net forum products were considered to contain SEI-related content[50], it could be calculated that during the 2010 NanoDays less than one percent of the encounters (0.4%) were with forum products. In fact, nearly all of the encounters were with one type of product – the hands-on activities (93.6%) (Table 17) (Pattison, et al., 2011).

Table 17. Estimated number and percent of visitors experiencing different NISE Net product types in 2010.

	Estimated Number of Total Encounters	Estimated Percent of Total Encounters
Hands-on Activity	407,622	93.6%
Exhibit	21,082	4.8%
Stage	3,304	0.8%
Forum	1,845	0.4%
Classroom	1,555	0.4%
Total	**435,408**	**100.0%**

Note. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Finding 5: There are opportunities for NISE Net to expand SEI-related educational experiences in Years 6-10.

A review of the Years 1-5 NISE Net research and evaluation reports, as well as a re-analysis of the NISE Net Forums formative evaluation database, indicate that there are a variety of opportunities for NISE Net to expand its societal and ethical implications offerings during Years 6 – 10. The overall themes about this finding are the following:

- Some NISE Net institutions reported that they were interested in learning more about SEI content.
- Members of the public reported that they valued discussing nano and SEI content with others even though this was not what initially attracted them to the forums.

[50] Traditionally, forums have been most likely to contain SEI-related content.

Some NISE Net institutions reported that they were interested in learning more about SEI content.

During its first five years, NISE Net conducted a series of workshops intended to educate informal science education (ISE) institutions about and interest them in NISE Net products. Evaluations of NISE Net Regional Workshops indicate that many Tier 2 and 3 partners have an interest in learning more about the societal and ethical implications of nanotechnology. However, fewer of these individuals report they are actually interested in implementing SEI-related products such as forums at their institutions. These findings indicate that there is an opportunity for NISE Net to expand their practitioner workshops to contain more SEI content. However, in order to get ISE institutions to present SEI to the public, it will likely be necessary to include SEI content in products other than forums.

During both the 2008 and 2009 NISE Net Regional Workshops, participants were asked about their interest in utilizing different NISE Net products at their museums. For both of the workshops, results reveal that practitioners were less interested in presenting forums than other products at their institutions. According to the *NISE Network Regional Workshops: Round One 2008 Formative Evaluation Report*, 51% of the survey respondents said they were interested in using NISE Net forum offerings. However, more participants said they were interested in using NanoDays materials (97%), programs (92%), and exhibits (58%) (Grack Nelson & Philippe, 2008). During the 2009 Regional Workshops, 44% of the question respondents said they were interested in using the forum program. However, once again, a greater percentage of participants said they were interested in using NanoDays materials (98%), programs (81%), and exhibits (51%) (Table 18) (Grack Nelson, 2009).

Table 18. 2008 and 2009 Regional Workshop participants' interest in using NISE Net products.

	Total Number of Question Respondents	Number of Respondents Saying "Yes" to Interest in Product	Percent of Respondents Saying "Yes" to Interest in Product
2008 Regional Workshops			
NanoDays Materials	64	62	97%
Programs	64	59	92%
Exhibits	64	37	58%
Forums	63	32	51%
2009 Regional Workshops			
NanoDays Materials	44	43	98%
Programs	43	35	81%
Exhibits	43	22	51%
Forums	43	19	44%

Note. Adapted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009; and "NISE Network Regional Workshops: Round One 2008," by A. Grack Nelson and C. Philippe, 2008.

As a part of the 2009 Regional Workshops' evaluation, participants were also asked about the kinds of products they were interested in learning more about or receiving trainings in. Results

from the evaluation indicate that many ISE professionals were interested in learning more about SEI content (84%) with only an interest in learning about holding NanoDays (89%), connecting nano to your programs (88%), and funding sources for nano content (87%) ranking higher. However, a smaller percentage of the participants were interested in learning about presenting forums. Only 58% of survey respondents said they were "interested" or "very interested" in attending a workshop/learning more about holding a nano forum at their institutions (Table 19) (Grack Nelson, 2009). In part because of the interest expressed by the Regional Workshop participants, NISE Net partners plan to include more information about nanotechnology societal and ethical implications content as a part of the Year 7 Regional Workshops.

Table 19. 2009 Regional Workshop participants' interest in workshops/sessions to learn about different NISE Net products (Grack Nelson, 2009).

	Percent of Respondents "Not at all Interested"	Percent of Respondents "Somewhat Interested"	Percent of Respondents "Interested"	Percent of Respondents "Very Interested"
a. Holding NanoDays at your institution (n=90)	3%	6%	23%	68%
b. Connecting nano to your programs (n=90)	3%	7%	28%	62%
c. Funding sources for nano activities (n=92)	4%	9%	28%	59%
d. Societal and ethical implications of nanotechnology (n=94)	1%	15%	30%	54%
e. Overview of various nano topics (n=92)	3%	10%	37%	50%
f. Nano in youth programs at your institution (after-school programs, summer camps, etc.) (n=91)	1%	15%	35%	48%
g. Marketing nano activities to public school audiences (n=92)	4%	11%	38%	47%
h. Developing a nano-literate floor and program staff (n=93)	7%	9%	40%	45%
i. Connecting nano to your exhibits (n=90)	4%	18%	34%	43%
j. Nano in formal education programs and resources (field trips, outreach, curriculum materials, etc.) (n=93)	4%	19%	38%	39%
k. Working with researchers and industry representatives to deliver nano programs and exhibits (n=93)	3%	22%	38%	38%
l. How to evaluate exhibits and programs (n=92)	7%	25%	34%	35%
m. Using the web to support community and share information (n=92)	3%	25%	41%	30%
n. Universal design of	11%	23%	36%	30%

exhibits and programs (n=90)				
o. Holding a nano forum at your institution (n=92)	11%	32%	32%	26%
p. Nano at children's museums (n=89)	16%	29%	19%	36%
q. Creating nano media – TV, film, web (n=93)	25%	36%	24%	16%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

Members of the public reported that they valued discussing nano and SEI content with others even though this was not what initially attracted them to the forums.

Findings from the NISE Net Forums formative evaluation database and the NISE Net Forums summative evaluation indicate that public participants appreciated learning about and having discussions about the societal and ethical implications of nanotechnology during the forums. In particular, many participants reported enjoying and being able to discuss the implications of nanotechnology with other members of the public. However, this discussion was not what attracted participants to the forums. Instead, it was the opportunity to learn about nano that initially caused the participants to attend the forums. Nevertheless, the positive reactions of public participants to the SEI content indicate that there is an opportunity for NISE Net to expand programming that includes discussion and SEI elements.

As stated above, participants were not initially attracted to the forums because of the program discussions. As a part of the forum formative evaluation, participants were asked a close-ended question about the key reasons they decided to attend the forum. According to results of this question, over three-quarters of the question respondents (82%) decided to attend because they wanted to learn about nanotechnology, and just under half (49%) decided to attend because they wanted to learn about the forum SEI-related topic.[51] Fewer participants reported that they decided to attend because of forum elements related to the forum discussion such as to hear others' perspectives (44%) or to share my ideas with others (13%) (Table 20).

[51] The topic visitors were asked about differed based on forum topic ("Nanomedicine": medical technology "Energy": energy technologies; "Privacy": privacy issues; "Consumer product labeling": consumer product regulation).

Table 20. Visitor Responses to the forum formative evaluation close-ended pre/post exit survey question: "What are the key reasons you decided to attend this event?"

	Total Number of Question Respondents	Number of Respondents who Picked the Option	Percent of Respondents who Picked the Option
To learn about nanotechnology	543	447	82%
To learn about the [forum topic][a]	511	251	49%
To hear others' perspectives	543	238	44%
Sounds like fun	543	178	33%
Professional networking	543	111	20%
To meet people, socialize	543	85	16%
To share my ideas with others	543	68	13%
To get involved at the museum	506	63	12%
Other	543	54	10%

a. The topic visitors were asked about differed based on forum topic ("Nanomedicine": medical technology "Energy": energy technologies; "Privacy": privacy issues; "Consumer product labeling": consumer product regulation).

Even though participants were not initially attracted to the forums because of the discussion, the forum formative evaluation found that participants enjoyed the forums and highly valued the small group discussion. The public participants indicated that they liked the forums overall. Almost all of them either "agreed" or "strongly agreed" with the statements "I enjoyed the experience" (98%) and "I would recommend the forum to others" (96%) (Table 21). Public participants were also asked an open-ended question about what aspect of the forum they valued most. Most commonly (24%) participants reported that they valued the opportunity to have discussions with others. Another aspect of the forum that participants valued related to the discussion was the opportunity to hear a diverse range of viewpoints (12%). Participants also reported that they valued the expert presentations. These participants said they valued the opportunity to learn and have access to information (20%) and the chance to listen and have access to experts (15%) (Table 22). Other aspects of the forum were valued by fewer public participants.

Table 21. NISE Net Forums formative evaluation participants' ratings of statements about their enjoyment of the forums. [52]

	N	Mean	SD	Percent of Respondents Who "Agree" or "Strongly Agree"
I enjoyed the experience.	885	3.5	0.6	98%
I would recommend the forum to others.	282	3.4	0.6	96%

[52] Forum participants were asked to rank these statements on a scale of 1 to 4 where 1 is "strongly disagree," 2 is "disagree," 3 is "agree," and 4 is "strongly agree."

Similar questions were asked as a part of the NISE Net Forums summative evaluation. As a part of this evaluation, public participants were asked if they would participate in a follow-up survey two weeks after the forum. On the follow-up survey, public participants were asked to rank the value of different aspects of the forum.[53] Public participants' average rankings were highest for the first (N=17, M=5.8) and second (N=17, M=5.8) expert presentations. Their average rankings were slightly lower for the "discussions in small groups overall" (N=17, M=5.1) and "sharing of discussion conclusions in big group" (N=17, M=5.2) (Flagg & Knight-Williams, 2008).

Table 22. Visitors' responses to the NISE Net Forums formative evaluation open-ended pre/post exit survey question: "What did you value most about this experience?" (N=908)[54]

	Number of Survey Respondents	Percent of Survey Respondents	Example Quotes
Discussing with others	221	24%	"The ethical discussion interested me." (Explo 2.2 Survey #15)
No answer	193	21%	--
Opportunity to learn/access to information	181	20%	"The knowledge gained about nanotechnology and its basic description and possible uses." (MLS 2.3 Survey #4)
Listening/access to experts	137	15%	"PPT presentation from Becky Thompson." (SMM 3.1 Survey #10)
Diverse range of viewpoints	109	12%	"The fact that folks from different backgrounds could discuss these issues." (MoS 3.3 Survey #5)
The topic of nanotechnology	91	10%	"Finding more about nanotechnology..." (OMSI 2.2 Survey #14)
Societal/ethical issues discussed	52	6%	"...the science and public policy intersection." (MoS 4.1 Survey #10)
The small group discussion and the experts	50	6%	"The sure information and communicating in discussion groups" (SMM Survey #5)
Other	41	5%	"I valued knowing that this information is being disseminated." (SMM 3.4 Survey #16)
Meeting other participants	36	4%	"Meeting others…" (MoS 4.1 Survey #20)
The format	17	2%	"...purposefulness of activity to illicit thought." (MLS 2.3 Survey #13)
The discussion scenarios	9	1%	"The opportunity to think through issues using concrete examples." (OMSI Survey #18)
The chance to consider their opinions	8	1%	"...exploring things in a way I hadn't thought of on my own." (Explo Survey #2)
The Forum environment	5	1%	"The open nature of the forum." (MoS 4.1 Survey #36)
The play	5	1%	"I really enjoyed the play…" (ASTC 3.1

[53] Participants were asked to rank the forum elements on a scale of 1 "not at all valuable" to 7 "extremely valuable."
[54] The total number of survey respondents is greater than 908 because some question responses fit into more than one code.

			Survey #13)
Everything	3	0%	"Everything! It was a very positive experience" (OMSI Survey #4)
Seeing what a Forum is like	3	0%	"Good to see an example and to reflect on the challenges of such a forum." (MLS 2.3 Survey #31)
The food	3	0%	"Cookies…" (OMSI Survey #38)
The topic of regulation	3	0%	"...Learning about what Cambridge do as city [sic]." (MoS 3.3 Survey #4)
The videotaped perspectives	3	0%	"The video presentation" (MoS 3.1 Survey #18)
That it was free	2	0%	"It was free…" (OMSI Survey #12)
The game format	2	0%	"...game format is engaging and non-threatening." (MoS 3.1 Survey #3)
The opportunity for networking	2	0%	"Getting 'plugged in' to the alternative energy & nanotech community" (Explo 3.4 Survey #2)
The topic of energy/alternative energy	2	0%	"Learning about...alternative energy." (MoS 3.1 Survey #12)

Conclusion

Since the very beginning of NISE Net, it was decided that public participants should learn not only about nanoscale science, engineering, and technology but also about the possible societal and ethical implications of nanotechnology. Therefore, the purpose of this chapter was to look across the evaluations conducted during Years 1 – 5 of NISE Net to understand the impact of societal and ethical implications products on the public. Evaluators did this in a number of ways. First, evaluators reviewed and summarized evaluation reports about societal and ethical implications products. Evaluators also looked at evaluation reports conducted about similar non-NISE Net products. Finally, evaluators re-analyzed portions of the NISE Net Forums formative evaluation database, which was utilized to generate the bulk of the findings presented in this chapter. Findings from all of these sources were triangulated in order to gain a clear picture of the impact of societal and ethical implications content about nanotechnology on the public.

Adding SEI content to NISE Net products does not mean sacrificing nanoscale science, engineering, and technology learning.

Evaluations of SEI-related products indicated that public participants learned about nanoscale science, engineering, and technology and its societal and ethical implications from them. Evaluations of the forums indicated that participants made significant gains in their knowledge of each of these topics. In addition, there was also some evidence that participants were more likely learn about nanoscale science, engineering, and technology than the potential risks and benefits of nanotechnology after these programs. Similar results were found as a part of the evaluations of non-forum SEI products. In these cases, members of the public indicated that the NISE Net exhibition, some stage presentations, and the NanoDays posters contained both SEI and nano content. However, there was variability in the proportion of the public that reported that the products contained SEI content.

There are a few possible explanations for these differences. Findings from the NISE Net Forums formative evaluation indicated that participants chose to attend because they wanted to learn about nanotechnology or the forum topic. Therefore, people using the SEI-related products may not have expected or been as interested in the SEI content and so have paid less attention to it. Additionally, participants may not have considered discussing or hearing about societal and ethical implications issues “learning.” Therefore, they did not report this is something that they learned as a part of the evaluations. Another consideration is that the amount and treatment of SEI content in the various NISE Net products differed. Therefore, the differences in reported learning may reflect that there is a threshold of content that a product needs to pass before the public learns about the risks and benefits of nanotechnology.

As the NISE Net continues its plan to expanding the number and type of products containing SEI content, the above findings indicate that it will be important to consider how much SEI content is being added to these products. It may not be enough to add only a few mentions. Instead, it may be important for a majority of the content to be SEI for it to be attended to. Since it is currently unknown whether there is a threshold of SEI needed to encourage SEI learning, NISE Net may want to study current and future SEI products to better understand if this threshold exists as well as what proportion of a product’s content needs to be SEI for the public to learn this content.

Even though the data from the Year 1 – 5 evaluations indicated that it may be difficult to get the public to focus on SEI content, the findings also implied that it is possible to add societal and ethical implications content to a product without compromising its ability to educate the public about nanoscale science, engineering, and technology. This implies that it may be possible for NISE Net to add SEI content to existing products and still expect that the public will learn the nano content. Nevertheless, it may be useful to study what impact adding SEI content has on the learning of the public in order to ensure that current impacts remain intact.

The public valued the opportunity provided by the SEI products to participate in discussions about nanoscale science, engineering, and technology.

Findings from the forum evaluations indicated that public participants were generally confident in their ability to express their opinions about nanotechnology even before the programs. However, public participants reported that the forums boosted their confidence. Additionally, participants reported that the forums gave them a chance to expand their understandings of the views of others as well as help them to consider both the positive and negative aspects of nanotechnology. Public participants reported that they valued the chance to have these kinds of discussions in a safe, neutral atmosphere.

Because the forums increased participants' interest in and confidence about discussing nanoscale science, engineering, and technology, NISE Net may want to consider expanding the use of forum discussion elements into other types of products. If NISE Net decides to add discussion elements to other kinds of products, it may want to explore how attractive forum-like discussions are to non-forum participants. Additionally, it may want to study what elements need to be present in order to make participants feel at ease during a discussion.

Besides valuing and enjoying discussions about nano, some forum participants and visitors who used the NanoDays posters reported that they continued thinking about nanotechnology after their experiences by having discussions with others about it or by paying more attention to this content in the media. There may be a number of explanations for this extended interest in nano. First, it is possible that an intensive experience like the forums spurred continued interest in the topic. Second, it is possible that by boosting participants' confidence in their knowledge and understanding of nanotechnology they were more likely to want to learn more about the topic. A third possibility is that the forum participants were already predisposed to have an interest in nanotechnology, and that they would have continued learning about nano whether they had attended the forum or not.

Because the findings about continued learning due to the SEI products were limited, NISE Net may want to further study what elements need to be present in order to encourage visitors to continue their learning after their nano experience. Additionally, because evaluators did not look at non-SEI products during Years 1 – 5 to see if they were also capable of encouraging continued interest and learning, NISE Net may want to study whether only SEI products or any kind of NISE Net product is capable of this.

Different demographic groups were attracted to different forum topics, which may have implications for future NISE Net products.

While very few public participants experienced SEI-related products, compared to all the visitors who used NISE Net products in Years 1 – 5, these products still reached many thousands of people. Therefore, it was possible to learn some interesting things about the specific impacts

of these products on the public. One of these findings was that the demographic groups attracted to the different forum topics differed. For example, males were more attracted to SEI products about energy than females. Additionally, the topic of privacy seemed to attract more young adults to forums while energy attracted more older adults. Finally, more non-whites were attracted to forums about medicine.

These findings have the potential to impact not only future NISE Net SEI products but all NISE Net products. This is because these findings indicate that the topic of products may impact the members of the public who are attracted to use them. Therefore, if NISE Net is considering targeting specific demographic groups, they should think about the content topic that they choose for those exhibits and programs. If NISE Net wants to attract more men, they may want to pick the topic of energy. If they want to attract more non-whites, they may want to choose topics such as medicine or provide more practical rather than theoretical kinds of information.

Unfortunately, the findings about age and products topic were less conclusive. It appeared that young adults were more attracted to forums about privacy while older adults were more attracted to forums about energy. However, there might have been some sampling bias associated with the age data. Therefore, before NISE Net uses the findings about the age to choose future content topics, further studies should be conducted on current and future SEI products. Additionally, there was little information collected from children under the age of 18. Therefore, it may also be useful to better understand whether children are more likely to be attracted to some content topics over others.

Societal and ethical implications products were not a major focus of NISE Net products in Years 1-5, but it appears that partners are interested in learning more about this topic in the future.

A conscious decision was made during Years 1-5 of the NISE Net to explore and slowly add societal and ethical implications content into Network products. At first, the only product to focus on SEI content was the forums. Other products that provided an overview of nano sometimes also contained a bit of this content. By Year 5 a greater variety of products focused on SEI content including museum theater, stage presentations, exhibits, and media. However, because few products contained SEI content and because the products that did contain SEI were not widely used by NISE Net institutions, evaluation findings indicate that few members of the public learned about the societal and ethical implications of nanotechnology content through NISE Net during its first five years.

There are a number of reasons why SEI products reached few members of the public in Years 1-5. First, societal and ethical implication is a new content area for many informal science education (ISE) institutions. Therefore, NISE Net has been slowly and purposely adding this content to their products. Second, NISE Net chose to focus its initial integration of this content into a forum format. While this format is optimal for SEI content, it is a format that is unfamiliar to many ISE institutions, and one which requires considerable staff, organizational resources, and expertise to implement. Additionally, even when the forums were implemented, it was found that they often attracted fewer visitors that other types of formats. Finally, some NISE Net members reported that they did not feel that SEI content was appropriate for their core visitors: children and their families. All of these issues likely contributed to the low use of NISE Net SEI products in Years 1-5 by museums and their patrons.

NISE Net plans on expanding both the number and types of products that contain SEI content in Years 6-10, which should address these issues. However, the product development teams may

want to consider continuing to study the utilization of the SEI products to ensure that NISE Net is creating products of most use to their partners. Additionally, they may want to think about looking at how children engage with SEI content and what they learn from SEI products in order to understand whether these products are appropriate for all age levels.

Even though few organizations used the SEI products in Years 1- 5 of NISE Net, findings from some of the partner workshops indicate that there is an interest among ISE professionals in learning more about this topic. Evaluations of 2008 and 2009 NISE Net Regional Workshops showed that a large proportion of the attendees were interested in learning more about the potential societal and ethical implications of nanotechnology. Additionally, close to half of the Regional Workshop participants indicated that they were interested in using the forums in the future.

These findings indicate that NISE Net's decision to expand SEI products in Years 6-10 will likely fulfill the interests and needs of the Network partners. The addition of SEI content to the Year 7 Regional Workshops will also likely be welcomed by ISE educators. Adding this content should help to address the needs of ISE professionals to have a stronger knowledge base about this content and better understand how to implement SEI educational products in their institutions.

5

Making the Unfamiliar Interesting and Relevant for Museum Visitors

By: Christine Reich

Introduction

Interest and relevance are two distinct, yet related goals of informal science learning. Generating visitor interest in and increasing the perceived relevance of nanoscale science, engineering, and technology (nano), however, are not simple endeavors. Nano is an unfamiliar topic for many museum visitors. Findings from large-scale national and international surveys repeatedly demonstrate that the public is largely uninformed and unaware about nano and its current and potential applications (Flagg, 2005c; Scheufele, 2010). This lack of familiarity poses a challenge for NISE Net professionals who seek to present nano content to museum visitors in a way that is both interesting and relevant. Interest in a topic and perceived relevance both stem from familiarity. It is difficult to be interested in or curious about a topic unless one has been exposed to the topic in the past (Hidi & Renninger, 2006). Lack of familiarity also makes it difficult for visitors to immediately know the connections between the content and their everyday lives. As part of the NISE Network's Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of NISE Net since its inception in 2005 and provide an overarching summary to the NISE Network and the broader ISE field. The *Interesting and Relevant* chapter highlights what the NISE Network has learned about ways to create nano informal science education experiences that are interesting and relevant to museum visitors.

Visitor interest is often recognized as a critical aspect of any informal science learning experience. In informal learning environments, where visitors are afforded the choice about which content and activities they do and do not want to attend to (Falk & Dierking, 2000), generating visitor interest in learning activities is essential; if visitors do not find a particular experience interesting, they are unlikely to stay, engage, and attend to the content.

Interest, however, is not just a pathway to engaging visitors with another content-related goal, but instead is also a goal itself. Interest is the first of the six "interrelated aspects" (p. 4) of informal science learning that was identified in the National Research Council report *Learning Sciences in Informal Environments* (National Research Council, 2009):

> *Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world* (2009, p. 4).

Hidi and Renninger (2006) define **interest** as a "psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time." Through this definition, the authors draw a distinction between interest in a particular activity or content area during a specific moment in time (situational interest) and longer-term interest that leads one to continually seek out opportunities to engage with or to learn more about an activity or topic (individual interest).

Similar to the definition of interest, **relevance** refers to both perceptions of the immediate experience and broader, longer-term connections to the topic. The term relevance can refer to either "pertinence to the matter at hand" or "applicability to social issues" (Houghton Mifflin Company, 2006). Relevance is a way for visitors to create a personal connection between nano and their everyday lives. Such a connection is thought by those who created NISE Net educational products to either foster immediate engagement with a particular exhibit or program, or continued learning about nano after participation with an exhibit or program.

Unlike interest, the term relevance does not appear in the learning strands annunciated in *Learning Sciences in Informal Environments*. The sixth strand of informal science learning does, however, connect to ideas of relevance as individuals who perceive nano as something that is relevant to their lives are more likely to identify with the content:

> *Strand 6: Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science* (National Research Council, 2009, p. 4).

In recent years, increased attention has been placed on the importance of perceived relevance for building a learner's relationship and identity with science, and for fostering continued learning about a particular topic (in other words, relevance is believed to be important for maintained situational interest and longer-term individual interest). The Relevance of Science Education (ROSE) international study, in particular, seeks to make classroom science more relevant for students by exploring "their interests, perceptions, experiences, attitudes, plans, and priorities" as related to science, with the assumption that enhanced relevance will mean that students will be more likely to develop an on-going relationship with science" (Chang, Yeung, & Cheng, 2009; Jenkins, 2006; Schreiner & Sjoberg, 2007). It is interesting to note that this study defines relevance in terms of interest. In other words, the ROSE study suggests that interest and relevance are not independent goals, but rather are related to one another.

This chapter of the Review yields insights on the educational goals of interest and relevance based on findings from NISE Net evaluation studies conducted within the first five years of the Network. It looks at the meaning of both interest and relevance of nano content for museum visitors and NISE Net professionals, and examines the potential, if any, relationship between these two goals for visitors and professionals. This chapter seeks to achieve this aim by acknowledging the possible link between interest and relevance, while simultaneously unpacking potential differences.

Lessons learned by NISE Net about ways to make nano interesting and relevant may have applicability to museums that are addressing other topics related to emerging science or current technology. Such topics can be unfamiliar to many visitors. They are also often in a speculative phase, where the potential applications and implications are still largely unknown. The findings in this chapter of the report, therefore, will hopefully serve not only to inform the next five years of NISE Net activities, but also other informal science education projects or initiatives that address topics related to emerging science or current technology.

Methods

This section of the Review drew from four data sources:

- The NISE Network Exhibits and Programs formative evaluation database containing data from Years 1-5 (representing data from 1494 visitors who interacted with a variety of exhibits and programs),
- Evaluation studies where relevancy was determined to be a primary or secondary theme (22 studies reviewed),
- Data from educator reviews of NISE Net exhibits and programs during Years 1-5, and
- Email communication with core members of the NISE Net Exhibits and Programs working groups who were involved in the Network throughout Years 1-5.

Data from the NISE Network Exhibits and Programs formative evaluation database were used to identify the key aspects of NISE Net learning experiences that visitors found interesting and relevant. The NISE Net Exhibits and Programs formative evaluation database is the most comprehensive resource for obtaining this information, as visitors were consistently asked about interest and relevance during the formative evaluation of exhibits and programs during the first five years (while the formative evaluation of other educational products did not always address interest or relevance). The data included in this database reflect visitor interactions with a wide variety of exhibits and programs that employed a diverse range of strategies and techniques to generate visitor interest and relevance. Analysis of the aggregated exhibits and programs formative evaluation data included non parametric statistical tests (data were largely categorical), as well as inductive coding of qualitative visitor comments. The inductive coding was conducted by two evaluators from the Museum of Science who worked closely with one another to develop a shared coding framework through multiple iterations. Staff members from the Science Museum of Minnesota who had been part of the initial data collection also provided input into the coding scheme. When analyzing the data from the NISE Net Exhibits and Programs formative evaluation database, care was taken not to aggregate data across programs and exhibits when performing inferential statistical tests as not all programs and exhibits were represented equally in the dataset. Instead, analyses generally focused on program comparisons.

Review of other evaluation studies was performed to further ascertain patterns and themes related to visitor interest and relevance that may not appear in the data collected as part of the exhibits and programs formative evaluation, and also to bolster patterns and themes that already emerged from the exhibits and programs formative evaluation. The reviewed reports included those identified by the Museum of Science Evaluation team, except for those reports where data from the reports could be analyzed directly through the aggregated dataset. Any evaluation report that summarized findings from the data analyzed within the aggregated NISE Network Exhibits and Programs formative evaluation database was excluded from the review of evaluation reports, as including these reports in both the study review and analysis of aggregate data would have compounded the influence of these data on the findings. Key findings from each reviewed report that was connected to the topic of interest and relevance were summarized in an Excel file and then sorted to determine areas of commonality across reports. These reports include the following:

- Multimedia Research reports:
  - *Nanotechnology and the Public: Part I of Front-End*
  - *Compilation of Nanoscale Communication Projects: Part IIA of Front-End*

  - *Compilation of Nanoscale Communication Projects: Part IIB of Front-End*
  - *Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Health Care*
  - *Impact of Sci-Tech Today Nanotechnology Cable News Segments*
  - *Impact of Television Presentation Formats on Understanding DragonflyTV Nano Content*

- Museum of Science reports:
  - *Nanotechnology Onstage at the Museum of Science: Presentation Review*
  - *Nanomedicine Explorer Interactive Multimedia Kiosk*
  - *"Treating Tumors with Gold" Stage Presentation formative evaluation*
  - *"Computing the Future" Stage Presentation formative*

- Science Museum of Minnesota report:
  - *NISE Net Exhibits and Programs Marketing Survey Formative Evaluation*
  - *NISE Network Regional Workshops: Round One 2008*
  - *NISE Network Regional Workshops: Second Round of Workshops*
  - *Exhibit & Program Summative Evaluation -- Year 4 Progress Report*

- Exploratorium reports:
  - *Scale Ladders: Communicating Size and Scale*
  - *Visitors' Drawings of Small*

- The Franklin Institute reports:
  - *Small Wonders: Nano Gold Demo*
  - *Small Wonders: Nano Sun Block Demo*
  - *Small Wonders: Photochromic Lens Demo*
  - *Small Wonders: Nano-Tex Fabric Demo*
  - *Small Wonders: Find the Nano in Your Life Summative*
  - *Small Wonders: "Liquid" Metals Demonstration Evaluation*

Data from professional reviews of NISE Net exhibits and programs were used to identify the kinds of program or exhibit attributes educators thought were important for generating visitor interest. During Years 1-5, professionals from NISE Net subawardee institutions (or Tier 1) would periodically meet and review each others' prototype programs and exhibits using a survey that was comprised of various rating scales and open-ended questions. Data from the professional reviews of NISE Net exhibits and programs were extracted from existing reports, entered into an Excel file, and analyzed using descriptive statistics.

To further identify the strategies NISE Net professionals felt were important for visitor interest and relevance, at the end of Year 5, a core group of seven NISE Net professionals from subawardee institutions were asked to share their thoughts (via email) on the topic. These professionals included those who had been actively involved in the development of NISE Net exhibits and programs during Years 1-5. Their thoughts provide insights on how NISE Net professionals had thought about interest and relevance as they created their products, and in turn, provide insights on the kinds of experiences offered through NISE Net exhibits and programs to which visitors were reacting. These data, therefore, were used to both identify the theories of action that may have guided how exhibits and programs were designed and to inform the coding scheme for the qualitative visitor comments from the exhibits and programs formative evaluation.

Findings & Discussion

Finding 1: Visitors find NISE Net learning experiences to be interesting, despite reporting low levels of interest in nano before participating.

Visitors are less interested in nano than other topics before they participate in nano informal science education experiences.

Studies conducted as a part of or in affiliation with NISE Net confirm that visitors are less likely to be interested in nano than other topics *before* exposure to a nano learning experience. In a review of existing literature conducted during Year 1, Flagg (2005c) reports that prior studies conducted with members of the European public as well as U.S. science museum visitors found people are less interested in the topic of nano as compared to other current science-related topics (such as medicine, environment, internet, astronomy, and genetics). Years later, the *Year 5 Summative Evaluation of Exhibits and Programs* similarly found that museum visitors are less interested in the topic of nano than other science museum topics (Bequette, et al., 2011). In this evaluation, visitors were asked, before they experienced nano exhibits, how likely they would be to stop and explore exhibits related to nano and non-nano topics on a scale of 0 to 10. Compared to four other typical museum exhibit topics (space, dinosaurs, forensics, and biomechanics), the nano-related topic (labeled "Strange Matter") received the lowest ratings (see Table 1).

Table 1. Museum visitors' responses to "How likely are you to stop and explore an interactive exhibit about each of the following topics?"

Exhibit element	Mean (n=248)	Standard Deviation
Journey to Space: Take a trip to the International Space Station. Investigate how low gravity will impact your muscles and how you will react to being in space.	7.7	2.68
Life in the Cretaceous: Travel back in time 65+ million years and be a dinosaur. Learn about dinosaurs' environment and the plants, animals and insects that shared it.	7.5	2.67
Biomechanics: Fish that project their jaws out to half their body lengths to capture prey? Spider webs stronger than steel? Discover the marvels of natural engineering.	7.1	2.40
CSI - The experience: Go from crime scenes to laboratories and autopsy rooms, bringing to life the most advanced scientific techniques used by today's crime scene investigators.	7.1	2.96
Strange Matter: Zoom to the nanoscale and explore the super small. Manipulated molecules and test new nanotechnologies, like the odor resistant socks and antibacterial teddy bears.	6.6	2.67

Note. Reprinted from "Year 5 Summative Evaluation of Exhibits and Programs," by M. Bequette, G. Svarovsky, and K. Ellenbogen, 2011.

A qualitative study conducted by the Museum of Science (MOS) in Year 2 supports the finding that visitors have a lower interest level in nano than other topics. This study featured focus groups with local community groups who were underrepresented in MOS's audience for its adult

forum programs, which feature discussions about social issues related to current science topics. For the most part, the focus group participants expressed less interest in attending the nanotechnology-related forums than forums related to children and computer use, in part, because they did not see this topic as relevant to their lives and to others in their community:

> *If I'm working at McDonald's flipping burgers, this really has nothing to do with me... This would not get our attention. If it is something that is detrimental to our future, that is something we should know about, with some explanation that I need to know this for myself or my family... For me myself, [in order to attend] it would be, 'Come and learn about nanotechnology, receive a $50 something'.* (Chin & Reich, 2007, p. 12)

Although these findings suggest that many people are not as interested in nano as they are in other topics, there is also evidence that some museum visitors may be interested in learning about nano. Some of the participants in the above-cited focus group were interested in nano and had attended nano-related events at MOS. These participants tended to be those who reported familiarity with the topic even before attending the forum. In addition, a qualitative study conducted in Year 1 that examined visitor perceptions of a forum marketing description found that some visitors thought the prospect of learning about nano was one of the most intriguing aspects of the event (Reich, 2006). The following quotes exemplify some of the statements made by visitors when discussing why they would be interested in attending a nano forum event:

> *Curious about it [nanotechnology]. (MOS)*
>
> *I think the only frontier left is going small so nanotechnology is good. (Exploratorium)*
>
> *The possibilities of nano and how cool it is. (North Carolina Museum of Life and Science)*
>
> *Learning about the future of nanotechnology and how it affects us on a day to day aspect. (Science Museum of Minnesota)*

Furthermore, for those visitors who did choose to go to a nano-focused event, the nano content was a driver for attendance. Analysis of data collected as part of the formative evaluation of NISE Net forums found that interest in learning more about nanotechnology was one of the key reasons 82% of individuals decided to attend these events. Nano forums, however, were not always well attended. Toward the end of the first five years of the Network, forum organizers experienced difficulties attracting visitors to these events (Kollmann, 2011; Kollmann & Goss, 2011). The reasons for this low attendance is unknown, and can be attributed to a variety of factors besides low-levels of interest in the topic, including low levels of interest in the format and ineffective marketing of the events.

Overall, these findings suggest that nano is less interesting than other topics for museum visitors at the onset, although there does appear to be a small group of visitors who are interested in learning more about nano.

Visitors who participate in NISE Net learning experiences report that these experiences are interesting and engaging.

Findings from multiple studies suggest that visitors who participate in NISE Net learning experiences find these experiences to be interesting and engaging. As found in the analysis of

the NISE Network Exhibits and Programs formative evaluation database, the percent of visitors who rated the NISE Net experiences highly on interest (meaning they described the experience as either "I was so interested I'd do it again" or "I was interested, but wouldn't do it again") ranged from 72% to 100% depending upon the experience. The *Year 5 Summative Evaluation of NISE Net Exhibits and Programs* also found that visitors tended to rate these experiences highly with regards to interest, with 97% of the surveyed visitors who used the exhibits selecting either "I was so interested I'd encourage others to see it" or "I was interested, but I wouldn't encourage others to see it" to describe their level of interest. Exhibition visitors also ranked the nano exhibition more or equally as interesting as other exhibitions they had seen in the museum that day. In addition, 90% to 100% of the surveyed visitors who participated in the programs summative evaluation rated these experiences highly on interest (percent varies by program). While not a direct measure of interest, it is also worth noting that almost all of the forum participants who were surveyed as a part of the formative evaluation (96% to 99%, depending upon the topic) agreed or strongly agreed that they enjoyed their experience.

The large proportion of visitors who describe their NISE Net learning experiences as interesting or enjoyable suggests that these experiences are supporting a form of triggered situational interest amongst museum visitors (Hidi & Renninger, 2006). Triggered situational interest is "sparked" by environments or activities that promote positive emotions (p. 114). Such an interest is often short-lived, but can be an important precursor to the development of on-going interest in a certain topic or activity.

Data collected during the first five years of the Network do not permit us to know whether and to what extent visitors' reported interest in NISE Net learning experiences transformed into a more maintained interest in nano over time. Only the summative evaluation of a forum program (Flagg & Knight-Williams, 2008) conducted in Year 3 explored whether visitors continued to learn, think, or talk about nano after participation in a NISE Net learning experience. This study found that the majority of the forum participants continued to engage with the topic of nano after the forum event, with 76% paying attention to media reports about nano, 71% discussing the benefits of nano with others, 65% discussing its risks, 65% explaining what nano is to others, and 53% seeking more information about the topic. Although these numbers are quite high, they should be read in context; it is possible that the individuals who chose to attend the forum did so because of an existing interest in nano. Therefore, these evaluation findings do not provide an indication of whether the situational interest triggered by participation in a NISE Net learning experience contributes to maintained interest in the topic as the forum participants came to the event with an existing interest (82% of forum participants reported that they chose to attend because they were interested in learning more about nano) (Goss & Kollmann, 2011; Kollmann, 2011; Kollmann & Goss, 2011; Kollmann, Reich, & Lindgren-Streicher, 2009).

A small pilot study conducted in Year 4 does, however, suggest that it may be possible that deeper interest or engagement with the topic of nano can result from participation in other NISE Net learning experiences besides forums. As part of the *Pilot Nanoawareness Study, Year 4 Report* (Kiser & Benne, 2009), a small pilot study was conducted where 15 individuals who had participated in NanoDays were asked to participate in a phone interview months after the NanoDays event. NanoDays is an annual event where the public is introduced to nano through activities that are held at hundreds of museums and universities across the country and around the world. For most institutions, these events do not require participants to register in advance, as is required for forum events. Rather, visitors simply drop-in to NanoDays events as a part of their general museum visit, or as part of a special event at a university or other community location. This pilot study found that the participating visitors did discuss their NanoDays

experience with others after the event (13 of 15 respondents), although they did not see much information about nano in the media (only 5 of 15 respondents did so).

The NISE Net *Year 5 Summative Evaluation of Exhibits and Programs* further explored whether visitors may continue to seek out opportunities to learn about nano after participating in NISE Net learning experiences. In this study, the findings were mixed; visitors who participated in the NISE Net programs gave higher ratings to questions that asked about their interest in learning about nano in the future as compared to visitors who did not participate in the programs (see Table 2). Visitors who participated in the NISE Net exhibits provided lower ratings with regards to their interest in learning about nano in the future as compared to visitors who did not participate in the exhibits (see Table 3). The reason for the difference between programs and exhibits is unclear. It could be related to how the question was asked. It also could be related to differences in the kinds of visitors who were attracted to participate in programs versus exhibits. It could also be related to the kind of learning experience (program versus exhibit). It is also possible that the exhibit made visitors feel like all of their questions were answered, while the program led visitors to feel they had more questions to ask. This is an area that could be explored in future years.

Table 2. Mean of pre- and post-long program survey responses to "Assuming the opportunity presented itself, how interested would you be in doing each of the following . . ."

Way to teach or learn about nano	Long Pre-surveys (n=148)	Intro to Nano (Long) (n=119)	Energy and Nano (n=101)	Treating Tumors (n=113)
Informally/casually teach someone something about nanoscale science	2.81	4.09	3.70	4.58
Read a news story or popular magazine article about nanoscale science	5.01	6.26	6.00	6.66
Learn more about the use of nanotechnology in medical treatments	5.83	6.78	6.23	7.16
Learn more about the use of nanotechnology in a personal care product	5.09	6.28	5.70	5.97
Change what products I buy based on what I know or learn about nanotechnology	5.10	5.93	6.04	5.64

Note. Reprinted from "Year 5 Summative Evaluation of Exhibits and Programs," by M. Bequette, G. Svarovsky, and K. Ellenbogen, 2011.

Table 3. Frequency of responses in each category to "Would you want to learn more about nano?"

	Pre-exhibit Boston, MOS (n=56)*	Post-exhibit Boston, MOS (n=55)*	Pre-exhibit Little Rock, MOD (n=25)*	Post-exhibit Little Rock, MOD (n=66)*	Pre-exhibit Portland, OMSI (n=51)*	Post-exhibit Portland, OMSI (n=56)*
Yes	92.9%	78.2%	76.0%	57.6%	66.7%	92.9%
No	3.6%	7.3%	0.0%	18.2%	0.0%	3.6%

Note. Reprinted from "Year 5 Summative Evaluation of Exhibits and Programs," by M. Bequette, G. Svarovsky, and K. Ellenbogen, 2011.
*Not all interviews included this question.

In summary, despite the low level of interest visitors have in the topic of nano at the onset, visitors who participate in NISE Net learning experiences report that these experiences are interesting and enjoyable. This is noteworthy given that, in the early years of the Network, many NISE Net professionals recognized that generating visitor interest in nano learning experiences was a key challenge. It is unknown whether visitor interest in the immediate nano learning experience translates into further interest in learning about nano over time. This, however, was not one of the stated goals in Years 1-5, where the primary focus was on the challenge of creating experiences that triggered visitors to be interested in an experience about a topic that is unfamiliar and (initially) uninteresting for many. Now that NISE Net has met this initial challenge, it may want to consider whether fostering longer term interest in nano could or should be the next challenge it undertakes.

Visitors attribute their interest in the exhibit or program to a variety of factors, primarily related to the content and type of experience.

Across evaluation studies, visitors were asked to describe what about the exhibit or program they found to be enjoyable or interesting. Detailed examination of visitor responses to surveys conducted as part of the exhibits and programs formative evaluation, summarized in Table 4, reveals that amongst these responses, what visitors tended to report as being interesting reflected both the experiential (63%) and content aspects (37%) of the program or exhibit design. With regards to the experiential aspects that were interesting, visitors frequently referred to elements that were hands-on or interactive (25%), as well as those aspects that discussed particular features or aspects of the demonstrations (24%). With regards to the content of the program or exhibit visitors found interesting, applications or technologies tended to dominate visitors' comments (23%), a finding that is confirmed by other studies as well (Bronnenkant, 2009; Flagg, 2005c, 2009). Few visitors mentioned content related to nanoscale science or size and scale (7%).

The *Year 5 Summative Evaluation of Exhibits and Programs* points toward a similar conclusion. Visitors referred to experiential factors of the exhibit as the portion that made it enjoyable (such as the interactives or visual elements) as well as the content (whether it was general subject matter or medical content). The specific experiential factors and content topics mentioned by visitors appeared to vary based on the exhibit component being discussed[55]. For

[55] Due to study constraints, visitors were not asked to describe the aspects of the programs that they found interesting or enjoyable.

example, for the “At the Nanoscale” exhibit, it was the general content that the majority of visitors reported as interesting. For “Creating Nanomaterials,” it was the interactive elements. For “Regenerating Tissues,” it was the connection to medical subject matter that made this exhibit interesting for visitors. For “NanoLab,” adult visitors reported that it was the fact that the child enjoyed the interactive elements that made it interesting.

Table 4. Visitors' responses to the question "Can you show which part [of the exhibit or program] was most interesting?" in the formative evaluation of exhibits and programs.

Code	Number of Responses (n=474)	Percent of Responses*	Definition	Example Comments
Experience – Hands-on	117	25%	The interesting part was the experience that was hands-on or interactive.	"Bunny suit" "Cutting the paper" "The magnet part"
Experience – Demonstrations	114	24%	The interesting part was the experience of the live demonstration explaining a phenomenon.	"The baking soda and vinegar reaction" "The fire"
Content – Topic – Applications/Technologies	109	23%	The interesting part was the content about the topic of applications and technologies. These can be either nano or non-nano related.	"How the gold was used to kill the tumor." "solar power" "waterproof fibers"
Experience – Entertainment	49	10%	The interesting part was the entertaining part of the experience.	"It was a gameshow" "It was funny"
Content – Topic – Nano/Scale	31	7%	The interesting part was the content about the topic of nanoscale science or other items at the scale of atoms and molecules.	"Learning about nanoscience" "Antibodies and antigens"
All	24	5%	The interesting part was the whole program or exhibit.	"All of it" "I found the whole thing interesting."
Content – Topic – Risks/SEI	18	4%	The interesting part was the content about the topic of risks or societal and ethical implications.	"Global warming" "The future concerns related to nanotechnology."
Experience – Visuals	15	3%	The interesting part was the experience that was the visual aid.	"The slide show" "Giant displays of graphite"
Content – Topic – Other	15	3%	The interesting part was the content about another topic.	"About space" "The light waves"
Other	4	1%	Any comment that doesn't fit into the other themes.	"Not sure what I was doing." "Understandable for 6-8 year old kids"

Note. After coding responses as pertaining to either experiential aspects or content-related aspects, responses were further coded into experience type and content type.

Finding 2: Many visitors report that NISE Net exhibits and programs are relevant to their lives.

In Years 1-5, only two types of studies explored relevance, the exhibits and programs formative evaluation studies and the Years 4 and 5 exhibits and programs summative evaluation studies. Findings from these studies provide indications of the portion of the museum audience that found NISE Net exhibits and programs to be relevant as well as the aspects of NISE Net programs or exhibits visitors report as relevant.

During the formative evaluation of NISE Net exhibits and programs, visitors were asked two different questions that sought to determine the relevance of these nano learning experiences for visitors. On certain surveys, visitors were directly asked to define how relevant the learning experience was to their lives. On other surveys, visitors were asked if the program or exhibit connected to anything else visitors knew about or might think about. Of the visitors who were asked how relevant the exhibit or program was to their lives, 16% stated that the program or exhibit was "extremely relevant to my life" and a further 35% stated that it was "somewhat relevant to my life," for a total of 51% of visitors reporting that the experience was somehow relevant to their lives. When asked if the exhibit or program connected to anything they already knew about or thought about, only 43% said yes.

During the *Year 5 Exhibits and Programs Summative Evaluation*, the question was asked a bit differently. Visitors were asked whether the experience connected in any way to their lives. For the exhibition, 62% of the surveyed visitors expressed that the exhibit connected in some way to their lives. In addition, this evaluation found that visitors who participated in NISE Net exhibits or programs were more likely than those who did not participate to report a connection between nano and their everyday lives. These findings are noteworthy given the lack of familiarity most visitors have with the topic of nano when they enter the museum.

Although a majority of the visitors surveyed as a part of the summative evaluation seemed to find NISE Net exhibits and programs relevant, there was still a substantial portion of the audience that did not. During the summative evaluation of NISE Net exhibits in Year 5, 38% of visitors did not see a connection between the nano exhibits and their everyday lives. Examining what visitors think makes a program or exhibit relevant may therefore provide insights on possible pathways to relevance that can be enhanced during the development of future NISE Net programs and exhibits.

As part of the formative evaluation of NISE Net exhibits and programs, visitors were asked to describe the part of the exhibit or program that was most relevant to their lives. Responses to this question provide insight into what visitors deemed to be relevant in the context of their experience with NISE Net exhibits and programs. As demonstrated in Table 5, there are multiple aspects of the program or exhibit that visitors referenced when describing what made it relevant during the formative evaluation, but the content of the program was most often mentioned. This contrasts with visitor responses to the question about interest (Table 4), in which the kind of experience was the prevalent response.

Applications and technologies were the content topics that were most often mentioned by visitors as relevant during the formative evaluation of exhibits and programs. The applications or technologies mentioned were not always nanotechnologies; in some cases visitors mentioned applications or technologies featured in the exhibit or program that were not based on nano (such as a Roomba vacuum or a specific energy technology). Regardless of whether or not the application or technology was a nanotechnology, this finding suggests that discussing

applications or technologies, particularly those that are nanotechnologies, is a strategy NISE Net should continue to employ to make nano relevant for museum visitors. It is also worth noting that nano programs developed by The Franklin Institute before the institution became a Network subawardee or Tier 1 partner tended to have high relevance ratings. Greater than 75% of visitors thought the programs were relevant or important to their life for five of the six programs where this question was asked. All six of these programs addressed applications of nano (Francies, 2008; The Franklin Institute, 2007a, 2007b, 2007c, 2007d, 2008). This is further confirmation that discussions of applications and technologies appear to be enhance the relevance of nano for visitors.

There were also many other reasons visitors provided during the formative evaluation of exhibits and programs for why the exhibits and programs were relevant. There were other content-related aspects mentioned by visitors, such as societal and ethical implications (14%) and nano/small things (9%). Beyond content, other categories of responses included aspects of the activity itself (14%), and connections individuals made between the program/exhibit and either their profession or their school work (9%). There were also some program or exhibit elements mentioned as relevant by fewer visitors, including connections to people (including scientists or others featured in the exhibit or program) (5%), the use of familiar objects in the program or exhibit (4%), and the importance/relevance of the experience to the child in the group (3%). All of these responses present ideas for strategies NISE Net can build upon to enhance the relevance of NISE Net learning experiences for museum visitors in the future.

It is difficult to determine if the topics that were mentioned less frequently by visitors were less salient overall for making an experience relevant, or if the less frequent mentions reflect the fact that these topics or activities are less prevalent in NISE Net exhibits and programs. For example, NISE Net programs and exhibits in Years 1-5 less frequently discussed risks or broader societal aspects of nano and more frequently covered topics related to applications/technologies or the science of nano (NISE Network Content Steering Group, 2010). If a topic is not included within a program or exhibit by museum educators, it is not likely to be referenced by visitors as the element of the program or exhibit that made it relevant for them. Therefore, there is room for NISE Net to explore the kinds of topics visitors find relevant as new topics, especially those related to societal and ethical implications, are introduced into its catalog of products. Formative evaluation of nano posters that feature societal and ethical implications (SEI) content found that nearly two-thirds of the visitors surveyed after viewing the posters thought that the content was relevant to their lives, which suggests there may be some untapped possibilities in this content area.

Table 5. Visitors' responses to the question "Which part of the [exhibit or program]'s content was most relevant to you?" in the formative evaluation of exhibits and programs.[56]

Code	Number of Responses (n=361)	Percent of Responses	Definition	Example Comments
Content – Topic – Applications/Technologies	111	31%	Mentions that what was relevant was a specific technology (nano or non-nano related) or an application of nano either now or in the future; could be an application of nano that is an object in the presentation	"It was relevant to my life because I realized they use nanogel everywhere for panels in buildings." "The fact that nano is used in Tupperware, socks and computers."
Content – Topic – Risks/SEI	51	14%	Mentions that what was relevant was the discussion of risks or societal and ethical implications. This includes any mention of the future since that will impact society	"The concerns" "The dangers of nano particles." "Understanding what the future would be like."
Activity	49	14%	Refers to what they saw or did; can include the exhibit name	"Building robots." "Liked watching the movie" "Smelling the smells"
School/Profession	33	9%	Connects to something connecting to one's own career, current or future or something studied in school or in the classroom	"I have been studying energy for a science project." "I am a nurse."
Content – Topic – Nano/Scale	32	9%	Mentions that what was relevant was something related to nano or at the scale of atoms and molecules	"The atom part" "nanotechnology"
Other	29	8%	Any comment that doesn't fit into the other themes	"Reflections downstairs" "the dino exhibit" "all of it"
Child	18	5%	When an adult mentions what was relevant for the child, or importance for teaching a child about the content, or activity is interesting for the child	"Kids learned." "Because my son is learning about meters in school."
Objects	16	4%	Mentions an everyday object in the program/exhibit	"The gears" "Safety goggles"

[56] This table also includes a small group of comments made in response to the question, "In what ways does this exhibit connect [to anything else you might know or think about]?" This question was asked in place of the relevance question during certain data collection sessions related to the formative evaluation of NISE Net exhibits and programs.

All	13	4%	What was relevant was all or everything	"All of it" "Everything they said"
Don't Know	12	3%	Says they don't know why it was relevant or what was relevant	"Didn't really understand." "?" "I don't know"
People	12	3%	Mentions a connection to people - either the people of nano/scientists/ engineers or someone they know personally	"The part about doctors" "We know people with tumors and cancer..."
Interesting	6	2%	Says it was relevant because it was new or interesting information	"Interesting topic today" "Interesting topic today"

In summary, the majority of visitors who participated in the summative evaluation of NISE Net exhibits and programs felt that these learning experiences engaged them with content that was relevant to their lives. There is still, however, a substantial number of visitors who did not feel that these experiences were relevant. If NISE Net wishes to improve upon the relevance of NISE Net exhibits and programs for museum visitors, it may consider building upon strategies that have proven to be successful in the past (such as discussing potential applications and technologies, which is a strategy that may be easier to employ as more nanotechnologies are developed over time). NISE Net may also want to explore whether some of the other aspects of the programs and exhibits that were mentioned by a smaller number of visitors also have the potential to enhance the relevance for visitors if these strategies were employed more frequently by NISE Net professionals. To determine which strategies for enhancing relevance were not widely utilized by NISE Net professionals in Years 1-5, one needs to gain a deeper understanding of the strategies NISE Net professionals used to make programs relevant during the first five years.

Finding 3: NISE Net professionals' ideas of interest and relevance aligned with those of museum visitors.

The aspects of an exhibit and program that visitors perceive to be interesting and relevant are based not only on the prior backgrounds, experiences, and interests of museum visitors, but also on how that particular program or exhibit is designed. Visitors will not report that a particular aspect is interesting or relevant unless that aspect is present in the program or exhibit. The way NISE Net professionals designed the programs and exhibits to be interesting and relevant for museum visitors, therefore, influenced visitors' responses. For this reason, it is important to explore both visitors' and NISE Net professionals' perceptions of interest and relevance.

The museum professionals who designed and developed NISE Net programs and exhibits created experiences based on their own mental models of ways to engage museum visitors in learning about nano. These mental models were based on their prior understandings and shaped by their experiences working with museum visitors. Their mental models are not static, but instead change over time as they interact with the public during delivery of nano programming, receive feedback from visitors through formative evaluation, and discuss their ideas and strategies related to informal science education with one another.

NISE Net professionals feel it is possible to create informal learning experiences about nano that are interesting for visitors.

When NISE Net first began its efforts, informal science education professionals questioned whether it was possible to create nano learning experiences that visitors would find interesting and engaging. In Year 1, NISE Net surveyed 34 museum professionals who were not involved in NISE Net at the time and asked them about the hurdles that would need to be overcome before they offered nano exhibits and programs at their own institution. Lack of audience interest was one of the hurdles identified by these professionals. On a scale of 1 to 10, "audience interest" received an average rating of 6.1, placing this hurdle below "money as a hurdle" (average score of 9.1), equal to "marketing a difficult subject" (average rating of 6.2) and above "relevance to our mission" (average rating of 3.9), and "space for exhibits and programming" (average rating of 5.4).

Table 6. Concerns regarding common hurdles (n=33).

	Average Rating
Money to purchase or create nanoscience exhibits or programs	9.1
Marketing a difficult subject	6.2
Audience interest	6.1
Space for exhibits or programming	5.4
Relevance to our mission	3.9

Note. Reprinted from "NISE Net Exhibits and Programs Marketing Survey formative evaluation," by A. Grack Nelson and K. Ellenbogen, 2006.

At the end of Year 5, it is clear that the existing group of NISE Net professionals feel it is possible to create informal science education experiences about nano that visitors find interesting. In the fall of Year 5, a core group of NISE Net professionals from Tier 1 institutions communicated via email a number of strategies that could be used to make nano exhibits and programs interesting for museum visitors. In addition, professionals from Tier 2 seemed to believe that lack of visitor interest was not a barrier to facilitating nano informal science learning experiences with the public. The Regional Workshop formative evaluation reports show that only 13% of the workshop attendees (largely from Tier 2 institutions) thought that it was "mostly true" that "we would not expect nano topics to be of high interest to our audiences." None of the professionals thought it was "definitely true" that nano would not be of high interest to visitors, and a large majority (87%) expressed that this statement was either mostly not true or definitely not true (Grack Nelson, 2009; Grack Nelson & Philippe, 2008).

It is unclear whether the difference between the results from the Year 1 survey of professionals and the findings from the Regional Workshop formative evaluations reflect a true shift in how professionals thought about visitor interest in nano as this difference could be attributed to differences in the population of professionals who were surveyed (those participating in the workshops self-selected to be a part of a museum network focused on nano). However, these findings do highlight that the professionals who are currently part of NISE Net (whether part of Tier 1 or Tier 2) do not feel that visitor interest in nano is a barrier to implementing nano exhibits and programs. This sentiment aligns with visitor responses to existing NISE Net

learning experiences, where large portions of the visitors report that they find these experiences interesting and engaging, as is reported above.

Similar to visitors' reported interests, educators highlight hands-on or interactive experiences as a key strategy for generating interest.

Email communication with a core group of NISE Net professionals who had been involved in the Network for all five years suggest that there was no single strategy employed by the creators of NISE Net products to make the programs and exhibits interesting for museum visitors. The technique that appeared to be the most prevalent in the professionals' mental models was the use of hands-on or interactive experiences as a part of the exhibit or program. This strategy was mentioned by five of the seven professionals who discussed his/her strategies. Other strategies mentioned by three or fewer professionals included the use of activities that were open-ended or exploratory, the employment of a dynamic presentation style, keeping the content simple and jargon-free, utilizing topics or questions that are of inherent interest to visitors, engaging visitors in conversations, using games, connecting the nano content to issues that were socially relevant, and presenting the content in a visually appealing setting.

These thoughts echo those expressed by the NISE Net professionals who participated in peer reviews of the exhibits and programs during various NISE Net working meetings. During Years 1-5, NISE Net professionals would frequently review each other's experiences during workshops and other meetings. This form of peer review was an integral part of the exhibits and programs development processes. During these peer reviews, the participating professionals were asked about the elements of the exhibit or program they felt best "engaged visitors with nano content." This question provides some indication of what these professionals thought might interest visitors. Review of these comments again demonstrates that "hands-on/interactive" was a design feature of the programs or exhibits that the professionals frequently thought would engage visitors. This category was mentioned as an engaging aspect of 26 of the 28 programs and exhibits reviewed, with a median of 51% of the professionals specifically mentioning this aspect as engaging across all programs. Visuals, props, images, or graphics were also considered engaging aspects of the design. This aspect was mentioned across 28 of the 28 programs and exhibits reviewed, with a median of 25% of the educators mentioning this aspect across all programs and exhibits reviewed. Other aspects frequently mentioned include interesting information, relevance, easy to use, and enjoyable or fun.

Across both the email communication as well as the data from the peer reviews, hands-on or interactive experiences were highlighted as a key strategy for generating visitor interest. This was also a key aspect of the experience that was emphasized by museum visitors when they were asked about the aspect of the program or exhibit that made it interesting. Here again there is alignment between NISE Net professionals' thoughts about interest and visitors' responses to the experiences these professionals created.

Similar to visitors' responses regarding relevant aspects, educators feel that discussing technologies and applications of nano makes the programs and exhibits more relevant for museum visitors.

NISE Net professionals employed a variety of strategies to make the exhibits and programs relevant to museum visitors. According to email communication with the core group of NISE Net professionals where they were asked about their perceptions of both interest and relevance, these professionals felt that discussing the potential technological applications of nano research

was a way to make nano content more relevant for museum visitors (mentioned by 5 of 7 professionals). Also frequently mentioned (4 of 7) was connecting the nano content to visitors' prior knowledge, everyday life experiences, or topics of prior interest. Other strategies mentioned by one or two professionals included generating an emotional reaction within visitors, discussing the people behind the research, discussing local research activities, drawing connections between the content and the visitors' body, mentioning social problems, and using familiar objects within the program or exhibit. Many of these were also mentioned by visitors as aspects of a program or exhibit that they found relevant.

Other studies conducted by science museums that are currently partner institutions within the Network also highlight that professionals feel discussing technologies and applications is a way to make nano relevant for visitors. A study conducted by The Franklin Institute before this institution became a Tier 1 partner found that other museum professionals appreciated the focus the "Small Wonders" programs placed on applications and technologies as these professionals thought this focus would be important for visitors (Francies, 2008). Here again, there is alignment between the emphasis visitors placed on applications and technologies for finding relevance and the strategies of the museum education and exhibition professionals who created the experiences.

In summary, NISE Net professionals' understandings regarding interest and relevance align with the responses made by museum visitors during formative and summative evaluation of NISE Net exhibits and programs. NISE Net professionals recognize that nano informal science learning experiences can be interesting for visitors, which is a perspective that is confirmed by the findings from multiple NISE Net evaluation studies. These professionals also identify hands-on learning experiences as a way to make programs and exhibits interesting, and discussions of applications and technologies as a strategy for enhancing relevance. This is similar to what visitors reported as being the aspects of NISE Net exhibits and programs that made these experiences interesting and relevant. This alignment should not be interpreted, however, to mean that there is no further need for NISE Net professionals to seek new strategies for making nano informal science learning experiences interesting and relevant for museum visitors. The visitor responses recorded as part of the evaluation studies reflect not only what visitors bring to the museum (in terms of personal values, prior experiences, and interests), but also what NISE Net professionals offered them through the design and implementation of the nano learning experiences they created. There is room for NISE Net to explore new strategies and approaches for making nano informal science learning experiences interesting and relevant as the Network moves forward, and for testing these strategies with museum visitors.

Finding 4: Interest and relevance are not synonymous for visitors.

There is no definitive relationship between interest and relevance for visitors who participate in NISE Net programs and exhibits.

It is often implied that there is a relationship between interest and relevance. As stated in the introduction to this chapter, science education research studying the relevance of science for students assumes there is a connection between relevance and maintained interest in science (Chang, et al., 2009; Jenkins, 2006; Schreiner & Sjoberg, 2007). In addition, email communication with NISE Net professionals revealed that these individuals also believed there was a connection between relevance and interest, with some stating that relevance is one potential precursor to interest, and others stating that interest in a particular experience is needed to foster perceptions of relevance.

Data collected during the formative evaluation of NISE Net exhibits and programs were analyzed to explore potential relationships between interest and relevance for museum visitors who participated in NISE Net learning experiences. In this database, different exhibits and programs are represented in different proportions due to variation in the number of evaluation study participants and also the number of times a particular program or exhibit was evaluated. This means that certain programs are overrepresented in the database, while others are underrepresented. Therefore, to study any potential relationship between interest and relevance, the data could not be explored in the aggregate, rather relationships were examined within individual exhibits and programs.

In the exhibits and programs formative evaluation dataset, there are six individual programs where a sufficient number of visitors had been surveyed (over 40) to examine possible relationships between interest and relevance. Of these six programs ("Small science: updates in nanotechnology research" "Cutting it down to nano," "Surface area – cart demo," "Nanotechnology: small things with big risks and big benefits," "Intro to nano – stage presentation," and "Wheel of the future"), none demonstrated a definitive relationship between visitors' ratings related to interest and relevance, meaning there was no evidence that visitors who rated a program high for interest were more likely to rate a program high on relevance, or that visitors who rated a program low on interest were more likely to rate the same experience low on relevance.[57]

It is worth remembering that the formative evaluation of NISE Net exhibits and programs focused on triggered situational interest, meaning this evaluation focused on whether the learning experience itself interested visitors in the particular moment they were interacting with the exhibit or participating in the program. This evaluation did not seek to examine whether the program or exhibit fostered a longer term, maintained, or individual interest related to learning about nano outside of the museum context. Therefore, what we cannot tell from this dataset whether relevance is linked to a longer term interest in nano content. It could be that relevance is not important for generating immediate interest in a particular exhibit or program, but it is important if one wants to foster a longer term interest with a particular content area.

[57] Chi-square tests were conducted to explore whether high visitor ratings for interest corresponded with high visitor ratings for relevance. For exhibits and one program, the chi-square test resulted in a p value that was less than the critical value of the 0.05 level of statistical significance. In both of these cases, however, 50% of the cells had expected counts less than 5, which can account for the positive finding and therefore renders the test inconclusive.

While visitors who rated a program high on relevance were no more likely to rate the program high on relevance, visitors' responses to the open-ended questions asked during the formative evaluation do suggest that there may be potential areas of overlap between the aspects of an exhibit or program that generate interest or relevance. When describing what made particular programs or exhibits interesting or relevant, the topic of technological applications emerged as a response for both categories, for what made a program or exhibit interesting (23%) and what made a program or exhibit relevant (31%). In addition, hands-on or interactive activities were also mentioned with regards to the aspect of a program or exhibit that made it interesting or relevant. However, a stronger emphasis on hands-on experiences emerged from the visitor comments about what made a program or exhibit interesting than in the comments about what made the program or exhibit relevant.

More visitors rate NISE Net learning experiences higher on interest than they do on relevance.

Findings from both the formative and summative evaluations of NISE Net exhibits and programs demonstrate that more visitors describe NISE Net exhibits and programs as interesting than relevant. As shown in Table 7, the difference between the percent of visitors who rated NISE Net exhibits and programs as interesting as compared to relevant during the formative evaluation ranges from 9% to 64% depending upon the program. A cursory look at these findings suggests that visitor ratings for interest and relevance were not equivalent. This is further confirmed through a Wilcox Signed Rank Test, which compared programs according to the percent of visitors who ranked them highly on interest and highly on relevance. Results from this test show that there was a statistically significant difference at the 0.001 level of statistical significance between visitor ratings for interest and relevance for the programs in Table 7 ($n=13$, $z=-3.181$, $p=0.001$). This finding suggests that if there was a relationship between interest and relevance, relevance would be only one way to make a program interesting. Other strategies would also contribute to visitor interest given that, for some programs, there are wide gaps between the percent of visitors who rate a program interesting and the percent who rate a program as relevant (such as the 64% difference for the "Cutting it down to nano" program, as presented in Table 7).

Table 7. Comparison of visitors' ratings to the questions "How interesting was this activity?" and "How relevant was the [exhibit or program]'s content to your life?" in the formative evaluation of exhibits and programs.

Nano Programs	Percent High Interest	Percent High Relevance	Percent Difference
Nano factory*	100%	88%	13%
Nanotechnology: small things with big risks and big benefits*	81%	25%	56%
Wheel of the future	96%	38%	59%
Cutting it down to nano	72%	8%	64%
Intro to nano – stage presentation	96%	73%	23%
Small science: updates in nanotechnology research*	92%	47%	45%

Aerogel	93%	67%	27%
Inkjet printer	87%	60%	27%
Sizing things down	86%	36%	50%
Surface area – cart demo	96%	35%	62%
Keep clean demonstration*	91%	82%	9%
NanoRobots*	100%	91%	9%
Self assembly	75%	42%	33%

Note. Program names marked with a (*) were not finalized and included in the NISE Net online catalog.

In summary, there does not appear to be a relationship between how visitors rated their interest in and perceived relevance of NISE Net exhibits and programs. Visitors who rated a particular exhibit or program high on relevance were no more likely than visitors who gave a low relevance rating to rate that same experience highly for interest. In addition, more visitors rated particular programs as interesting than relevant. There does appear, however, to be some overlap in the reasons specified by visitors for why they thought particular exhibits or programs were interesting and relevant. In particular, the topic of technologies and applications was mentioned by visitors both when they were describing what made an exhibit or program interesting and what made it relevant to their lives. While there does not appear to be a correlation between how visitors rate their perception of relevance and their interest level when participating in a NISE Net program or engaging with a NISE Net exhibit, it is possible that perceived relevance could be associated with longer term interest in the content of nano. Unfortunately, data do not exist that would enable such an exploration at this point in time. This is an area for potential future examination.

Conclusion

The NISE Network began with a unique set of challenges. Nano is a topic that is unfamiliar to most visitors, which reduces the likelihood that this topic is inherently interesting or relevant to museum visitors. Further studies conducted through NISE Net confirmed that visitors are less interested in learning about nano as compared to other topics before participating in NISE Net learning experiences. Despite these challenges, NISE Net succeeded in creating informal science learning experiences about nano that visitors report are both interesting and relevant to their lives.

Across multiple evaluation studies, visitors reported that they found the NISE Net learning experiences they participated in to be interesting. This was true of the variety of learning experiences that were evaluated, including exhibits, programs, and forums. It is unknown, however, whether visitor interest in the immediate nano learning experience translates into further interest in learning about nano over time. This, however, was not one of the stated goals in Years 1-5, where the primary focus was on the challenge of creating experiences that triggered visitors to be interested in an experience about a topic that is unfamiliar and (initially) uninteresting for many. Now that NISE Net has met this initial challenge, it may want to consider whether fostering longer term interest in nano could or should be the next challenge it undertakes.

Review of previous studies also found that the majority visitors who participated in the evaluation of NISE Net exhibits and programs felt that these learning experiences engaged them with content that was relevant to their lives. There was still, however, a substantial number of visitors who did not feel that these experiences were relevant. If NISE Net wishes to improve upon the relevance of NISE Net exhibits and programs for museum visitors, it may consider building upon strategies that have proven to be successful in the past (such as discussing potential applications and technologies, which is a strategy that may be easier to employ as more nanotechnologies are developed over time). NISE Net may also want to explore whether some of the other aspects of the programs and exhibits mentioned by a smaller number of visitors (such as discussing SEI and making personal connections to people) also have the potential to enhance the relevance of NISE Net learning experiences for visitors.

NISE Net professionals' understanding regarding interest and relevance align in many ways to museums' responses about what made NISE Net exhibits and programs interesting and relevant. NISE Net professionals recognize that nano informal science learning experiences can be interesting for visitors, which is a perspective that is confirmed by the findings from multiple NISE Net evaluation studies. These professionals also identify hands-on learning experiences as a way to make programs and exhibits interesting, and discussions of applications and technologies as a strategy for enhancing relevance. This is similar to what visitors reported as being the aspects of NISE Net exhibits and programs that made these experiences interesting and relevant. This alignment should not be interpreted, however, to mean that there is no further need for NISE Net professionals to seek new strategies for making nano informal science learning experiences interesting and relevant for museum visitors. The visitor responses recorded as part of the evaluation studies reflect not only what visitors bring to the museum (in terms of personal values, prior experiences, and interests), but also what NISE Net professionals offered them through the design and implementation of the nano learning experiences they created. There is room for NISE Net to explore new strategies and approaches for making nano informal science learning experiences interesting and relevant as the Network moves forward, and for testing these strategies with museum visitors.

There does not appear to be a relationship between how visitors rated their interest in and perceived relevance of NISE Net exhibits and programs. Visitors who rated a particular exhibit or program high on relevance were no more likely than visitors who gave a low relevance rating to rate that same experience highly for interest. In addition, more visitors rated particular programs as interesting than relevant. There does appear, however, to be some overlap in the reasons specified by visitors for why they thought particular exhibits or programs were interesting and relevant. In particular, the topic of technologies and applications was mentioned by visitors both when they were describing what made an exhibit or program interesting and what made it relevant to their lives. While there does not appear to be a correlation between how visitors rate their perception of relevance and their interest level when participating in a NISE Net program or engaging with a NISE Net exhibit, it is possible that perceived relevance could be associated with longer term interest in the content of nano. Unfortunately, data do not exist that would enable such an exploration at this point in time; this is an area for potential future examination.

Overall, the work of NISE Net during Years 1-5 demonstrates that it is possible for museums to generate visitor interest in and perceived relevance of learning experiences that discuss topics that are unfamiliar and initially uninteresting to museum visitors. In addition, this work highlights the fact that visitor interest can be generated for a particular experience without visitors feeling the topic is relevant to their everyday lives. What is still unknown, however, is whether this generated interest in a particular exhibit or program serves as a precursor to a longer term interest in the topic, where visitors pay more attention to the topic when they come across it in the future or actually seek opportunities to learn more. What is also unknown is the extent to which and the ways it is possible to make visitors feel that these unfamiliar topics are also relevant to their lives. These are areas that warrant further research by the field.

6

Reaching Public Audiences through the NISE Network

By: Juli Goss and Christine Reich

Introduction

As part of the Nanoscale Informal Science Education Network (NISE Net) Public Impacts Summative Evaluation, the *Review of NISE Network Evaluation Findings: Years 1-5* seeks to investigate the work of the NISE Network since its inception in 2005 and provide an overarching summary to NISE Net and the broader ISE field. The *Reaching Public Audiences* chapter is an integral component to this document as it strives to provide insights on the public audiences targeted and the public audiences reached through NISE Net activities. This chapter begins by examining the public audiences targeted through NISE Net product development (both implicitly and explicitly) as well as the audiences who are the focus of public outreach activities implemented by NISE Net institutions. It then seeks to examine where there is existing or growing alignment between these efforts as well as outline opportunities for future alignment.

The NISE Net theory of action relies on both those who develop and disseminate educational products and those who implement educational products to reach the public. Unlike traditional informal science education projects where the product's developer and implementer are generally the same person or represent the same institution, the Network model consists of a group of institutions who create products together, and then not only use the products but also distribute the products for use by an even larger group of institutions. Some of the products developed by NISE Net, such as exhibits, are not extensively modified by host institutions. Other products, such as programs and facilitated activities included in NanoDays kits, are often modified by the host institutions. Nearly all NISE Net educational products have been developed to be open-source, and product developers have taken the probability for modification into account during the development process. Eventual modification by partners was always an explicit part of the Network's dissemination strategy and development process.

NISE Net relies on its partner institutions to attract and provide the audience for its products. The audience that is reached through NISE Net activities, therefore, is determined not only by NISE Net developers in that they are designing experiences, but also by all of the Network partners in that they are serving and marketing toward their own audiences. Therefore, it cannot be assumed that the intended audience as specified by the product developer will be the same as the intended audience served by the product implementer. When these audiences align, it provides an indication of the types of audiences who are actually reached and therefore those audiences who have the opportunity to learn about nanotechnology from the NISE Network.

In the original proposal for funding submitted to the National Science Foundation, the NISE Network broadly identified two public audiences as those they planned to target: the general museum visiting public and the audience of more engaged "science attentive" adults" (NISE Network, 2005). Since its inception, the Network has focused on audiences who are already drawn to science museum settings including family groups and the adult public. This chapter seeks to identify and describe the implied and probable audiences, including family groups, adult-only groups, and beyond, reached by the NISE Network institutions and partners. This identification is based on the efforts of the individuals in the Network who develop and disseminate NISE Net products and the efforts of the individuals in the Network who implement NISE Net products.

Audiences included in this chapter are not an exhaustive list of all audiences reached by NISE Net and Network partners. However, the audiences included are meant to provide an overview of audiences that have emerged due to Network activity. For example, one reason adult-only audiences are included is that they were the focus of a specific NISE Net product format; one reason younger audiences are included is that they have come to the forefront of audiences that are of interest for NISE Net partners. By using these criteria for including an audience in this chapter, and including those audiences who have displayed some level of activity from either Network product development and dissemination or Network product implementation, the types of audiences included at all Network levels can be examined. It is important to examine all aspects of audience in order to ascertain how the NISE Net is currently or could possibly capitalize on the experiences of partner institutions and vice versa.

Throughout this analysis of Network audiences and their alignment with Network activity, three categories of alignment emerged: clear alignment; growing alignment; and opportunities for future alignment. Family groups and adult-only groups are audiences for which there is evidence of alignment between Network development and implementation, despite the fact that this alignment is slightly different for these two group types. Although both audiences were included in product development at the beginning of the NISE Network, Network activity related to family groups occurs as expected. In contrast, adult-only groups appear to be reached by Network activity through multiple avenues that do not always include the activity format specifically developed for engaging adult-only groups.

Younger children and out-of-school time program participants are audiences for which there is evidence of growing alignment between Network development and implementation. These audiences have come to the forefront of Network development efforts as evidence has arisen of partners' interest and implementation.

Audiences for which there are opportunities for greater future alignment between Network development and implementation include Spanish-speaking audiences, people with disabilities, and school groups. These opportunities reflect moments in which NISE Net development and implementation have prioritized audiences in different ways. NISE Net has prioritized the audiences of Spanish-speaking audiences and people with disabilities and developed products intended for underserved or underrepresented audiences. In accordance with its mission, the NISE Network has not focused on the audience of school groups and the balance between sufficiently supporting partners' interests within an informal science education context continues to be addressed.

Methods

Findings from the *Reaching Public Audiences* chapter were derived from multiple sources covering multiple years of the Network:

- NISE Network Exhibits and Programs formative evaluation database, Years 1-5
- NISE Network Forums formative evaluation database, Years 1-5
- Analysis of the NISE Net online catalog of educational products, as populated at the end of Year 5
- Annual Reports for Years 1-5 and Year 5 communication with working group leaders
- Regional Workshops, Year 4
- Annual Meeting, Year 4 regional hub discussions
- *2010 Delivery and Reach Study*, Year 5
- Site Visits to Network partners, Year 5

This chapter seeks to summarize, across different studies and sources, what is known about the audiences of the NISE Network. This chapter looks across these sources of data to see if there is evidence of alignment between the audiences upon whom the Network focuses its product development and dissemination and the audiences reached by Network implementation of nano-related programming. Because it is the goal to look at the differences and similarities between these audiences, some sources are more internally-focused and include information about the *development* of NISE Net educational products while other sources are broader and capture information about the *implementation* of NISE Net products and other nano-based educational experiences by the Network partners. In order to make this distinction explicit, sources related to development and implementation are identified below.

The *Reaching Public Audiences* chapter differs slightly from other chapters of the Review in that few of the existing NISE Network Research and Evaluation reports have focused exclusively on defining the audiences reached. It is for this reason that findings are not only a representation of cross-study findings, but also a generation of findings from the mining of existing datasets and examination of Network actions.

NISE Network Development Sources

For the purposes of this chapter of the Review, NISE Network development refers to work conducted by Tier 1 institutions (those that receive direct funding from the NISE Net grant) in the creation and dissemination of nano educational products that will be implemented by Network partners. Development sources also refer to the facilitation of product dissemination conducted through the Network's community building efforts. Such work could refer to activities such as the development of nano educational products, the development of the Network through the establishment of regional hubs, or professional development as facilitated through the Network-wide meetings or workshops. The NISE Network has other organizational structures which will not be identified in the course of this chapter. In short, this work is distributed into working groups that are responsible for various aspects of the Network including, but not limited to, product development and distribution, community building, and grant management.

NISE Network Exhibits and Programs formative evaluation database

Demographics of participants of the formative evaluation of NISE Net exhibits and programs were analyzed in order to describe the audiences included in the evaluation of Network-developed products.

NISE Network Forums formative evaluation database

Demographics of participants of the formative evaluation of NISE Net forums were analyzed in order to describe the audiences included in the evaluation of Network-developed products.

Analysis of NISE Net catalog

In order to determine which audiences the Network has included in the development of catalog products, the "intended audience" for each public educational product was examined. These audiences were defined by the working groups and are listed with products in their online catalog entry. Tools designed to help professionals reach specific public audiences were also explored including the *Universal Design Guidelines for Exhibits* (NISE Network, 2010d), *Universal Design Guidelines for Programs* (NISE Network, 2008b), and the *NISE Net Public Forum Manual* (NISE Network, 2007a).

Annual Reports and communication with working group leaders

The Network's Annual Reports to the National Science Foundation were utilized in an effort to understand how the Network has documented its actions around audiences over time. Because each report contains narratives from each working group, it provides a glimpse into Network actions regarding work with all audiences, especially underrepresented audiences and younger audiences (NISE Network 2006, 2007b, 2008c, 2009b, 2010e).

This source was examined from a development and dissemination standpoint, even though Annual Reports contain some implementation information. Because Annual Reports include information regarding only Tier 1 institutions and data is not always systematically collected, the reports' appendices about Network implementation and partnerships were not analyzed for this chapter. Broader Network-wide implementation was derived from other sources.

For newer initiatives that had not yet been documented in report form, the working group leader was contacted so that this chapter could reflect the thinking of the Network through the end of grant Year 5 with some indication of plans for Years 6-10.

NISE Network Implementation Sources

NISE Network implementation is used here to describe the public educational activities of all Network partners. Network educational product implementation includes all efforts conducted by Tier 1, 2, and 3 partners that are aimed at directly engaging the public in learning about nano.

The level of activity varies greatly by institution but all partners have at least participated in NanoDays.[58]

As stated in the introduction, this report seeks to extend discussion to all Network audiences including, but not limited to, underrepresented audiences. However, it should be acknowledged that many times when discussion about audience has occurred with Network partners, it has been framed with the lens of reaching underserved audiences. For this reason, some of the sources used for this report questioned partners about all audiences while others featured data specifically related to underrepresented audiences.

Regional Workshops 2008-2009

The first and second rounds of Regional Workshops were offered between Fall 2008 and February 2009 as an opportunity for regional professional development of Tier 2 partner institution staff members. As part of these workshops, a representative of the NISE Net Diversity, Equity and Access (DEA[59]) group led partners in a discussion about how they engage underserved and underrepresented audiences at their institutions. The goal was for partners to gain new ideas on how to engage these audiences. Comments were recorded regarding each institution's strategies for reaching underrepresented audiences as well as which audiences they were reaching.[60] These comments were investigated for the purposes of this chapter to describe some reported audiences of partner institutions.

Annual Meeting 2009 discussion

One day of the Annual Meeting in September 2009 was dedicated to the question "How do we integrate nano beyond our general audiences?" Part of this emphasis included a discussion within each regional hub subgroup in which participants discussed the Network's DEA-related efforts. Individuals from all levels of involvement in the Network participated in a group activity by responding to the questions, "What are we doing within our region to positively impact the NISE Net DEA efforts?" and "What resources do we need to increase our efforts to bring nano to a diverse audience?" Answers were collected and examined here to describe the reported audiences of the Network.

2010 Delivery and Reach Study

The *Delivery and Reach Study* was designed to broadly document the delivery of nano education activities at Network partner institutions and estimate the public reach of those activities (Pattison, et al., 2011). This study gathered information from the NanoDays reports as well as a Network-wide survey of partners. Data related to the reach of activities to different audiences have been incorporated into this chapter.

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[58] NanoDays is a week-long, nationwide festival of educational programs promoted and facilitated by the NISE Net. Partners receive a kit of activities, hold events with their publics, and report back to the Network.
[59] The Diversity, Equity and Access (DEA) working group changed its name to Inclusive Audiences at the end of grant Year 5. This chapter uses "DEA" since the work included occurred prior to the group's name change.
[60] It should be noted that although Tier 1 professionals participated in and led these conversations, data from Tier 1 individuals were not included in this analysis.

Site Visits 2010

In the spring and summer 2010, members of the NISE Net Community Group visited 26 partner institutions in order to forge stronger relationships with organizations that had been highly involved with the Network to date, and to learn more about the nano education efforts underway at each of these partner institutions. Data from the 2010 Site Visits are incorporated into this chapter to provide examples of partner audiences.

Findings & Discussion

Finding 1: Family groups and adult-only groups are audiences for which there is evidence of alignment between NISE Network educational product development and implementation.

As mentioned previously, the types of public audiences who are currently reached by NISE Network institutions are influenced by both the strategies of the Network educational product and community developers, as well as the strategies of those who implement the products. The audience category of family groups emerged from both the work of NISE Network development as well as the educational programming implemented by Network institutions. This alignment shows how the initial thinking of the Network focused on a core audience of Network partners. The audience category of adult-only groups also shows alignment between development and implementation sources, yet offers a different view of how this can be achieved.

Family groups

Family groups are a traditional museum-going audience. This group type is typically comprised of one or more adults and one or more children who are not visiting as part of a school or camp group. As stated, the NISE Network proposal for funding outlines the fact that family groups, as part of the general museum visiting public, were a target audience of the Network since the beginning. Review of the data collected as part of NISE Net educational product development illustrates the implementation of this plan. Evidence of this can be found in data that describe the intended audiences of NISE Net products as well as data depicting who NISE Net products were evaluated with during formative evaluation. As shown in Table 1, the majority of the NISE Network catalog of products are intended to be enjoyed by visitors of all ages (41%) or those who are older than age seven (23%) or age eleven (26%). “All ages” encompasses adults and children of all ages, assuming that most children are accompanied by adults and largely as part of a family group. These audiences were established as “intended” because they were thought to be the most appropriate age for the product’s audience. According to communication with the working group leader, these “are the age categories that a program was developed for and evaluated with, but not necessarily the only audience the developer thought a program was suitable for.” Although it was assumed that the audience would vary depending on the implementer, the Network communicated the intended audience for each product to its partners through the Network website (www.nisenet.org). The website allows professional users to browse the online catalog by audience.

Table 1. Intended audiences for the public products listed in the NISE Net catalog.

Audience	Number of Programs Products[a]	Number of Exhibits Products	Number of Media Products	Total Number of Products	Percent of Products
All Ages	21	6	5	**32**	**41%**
7 and up	14	2	2	**18**	**23%**
11 and up	10	3	7	**20**	**26%**
15 and up	2	1	0	**3**	**4%**
Adult	4	0	1	**5**	**6%**
Total	**51**	**12**	**15**	**78**	

a. The four forum programs intended for the adult audience are categorized with the Programs format.

These products were also evaluated with visitors that the working group considered to be similar to family groups in that they are made up of one or more adults caring for one or more children who were not a part of a school group. Tables 2 and 3 shows that the majority of those who participated in product testing are older than age 19 (43%), age 11-14 (34%) or age 7-10 (16%) and slightly more female (60%) than male (40%) participants. Many of these adults could have been attending as part of a family group. Also, as the distribution is approximately split between adults and younger individuals, it suggests a reasonable balance for understanding the needs of all users in a family.

Table 2. Demographics of participants in formative evaluation of exhibits and programs.

Age	Total Number of Study Participants	Percent of Total Participants
0-6 years old	24	**1.79%**
7-10 years old	218	**16.22%**
11-14 years old	454	**33.78%**
15-18 years old	73	**5.43%**
19 and older	575	**42.78%**
Total	**1344**	

Table 3. Demographics of participants in formative evaluation of exhibits and programs.

Sex	Total Number of Study Participants	Percent of Total Participants
Male	579	**40.52%**
Female	850	**59.48%**
Total	**1344**	

The audience of family groups also emerged as one that is addressed by the Network's implementation of nano-related programming. Family groups as an audience appear both in the

Site Visit 2010 data and in the NanoDays 2010 data reported in the *2010 Delivery and Reach Study* (Pattison et al., 2011). As shown in Table 4, Site Visit partner institutions list families specifically as one of the audiences reached through their nano education activities (24 of 26 sites). When asked how they would describe the audiences reached through their nano educational programming, the majority of sites mentioned families, making comments such as the following:

> *When we do programming, we try to actively engage the whole family*
>
> *[We're] aimed at reaching families with children a little older - probably in middle school.*
>
> *On NanoDays, we have mostly families with very young children.*

Table 4. Audiences reached through nano education activities at institutions who participated in the 2010 Site Visits.[61]

Audience	Number of Sites Including Audience	Percent
Families	24	92%
Young audiences (preK)	13	50%
School groups at the museum	13	50%
Other	8[a]	31%
Teachers	7	27%
School groups – outreach to schools	6	23%
Adults only	6	23%
Out of school time groups	3	12%
Spanish speaking audiences	2	8%
People with disabilities	1	4%

a. 4 of these 8 are "homeschool groups".

The *Delivery and Reach Study* also found that family groups were an audience reported by partner institutions. This comes out in the 2010 NanoDays Reports filled out by partner institutions following their NanoDays events. When asked whether or not they noticed family groups, school groups, or adult-only groups at their institutions during the event, 84% of all respondents replied that they had implemented nano-related programming with family groups. Specifically, large museums and small museums were more likely to report family groups as an audience than universities and other types of institutions. Table 5 includes the *Delivery and Reach Study* findings based on respondents' self-reported data.

[61] These audiences were identified by Site Visit partner institution staff either during the Site Visit or in the follow-up interview which included the following open-ended questions, "How would you describe the audiences your institution reaches through nano educational programming?" and "Have you done any nano educational experiences targeted toward reaching underserved audiences?"

Table 5. Types of visitor groups reported by institutions in the NanoDays Report.

Visitor Group	Percent of Large Museums (N=25)	Percent of Small Museums (N=57)	Percent of Univ. & Other (N=59)	Percent of Total (N=147)
Family groups**	100%	95%	60%	84%
School groups	60%	46%	64%	56%
Adults-only groups	52%	28%	41%	37%

Note. *$p < 0.05$. **$p < 0.01$. Respondents reported whether or not they saw any groups of each type during the NanoDays event. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Adult-only groups

Adult-only groups are comprised of one or more adults who attend informal science settings without children. Activity related to the audience of adult-only groups has been occurring in the NISE Network since the beginning of Year 1. NISE Net development work groups put emphasis on creating all Network products as experiences that could be enjoyed by adults. Although only 6% of all current products are intended specifically for adult-only groups, 100% of products are intended for age ranges that include adults (Table 1).

NISE Network product developers also made a choice to create educational products that are intended specifically for adult-only groups. Designing programs for adults allows programs to provide more in-depth information, be longer in duration, and to include content that may be less appropriate for younger audiences. Adult-only groups were a new audience for some institutions in the NISE Net, and the corresponding educational product development work was mostly housed within the NISE Net Forums working group in Years 1-5. As stated in the *NISE Network Public Forums Manual*, "the overall charge" of the NISE Net Forums team was "to develop, test, and disseminate program models aimed at engaging adults and teenagers with informal educational experiences that incorporate discussion, dialogue, and deliberation around societal implications of nanoscale science, engineering and technology" (NISE Network, 2007a, p. 6).

There is also evidence that Network partners implemented nano education activities with adult-only audiences. According to the *2010 Delivery and Reach Study* of NanoDays, adult-only groups were served by 37% of the reporting institutions' NanoDays events (Table 5). This is a sizeable portion of all institutions, though not the majority, and provides evidence that adult-only groups are being reached.

It is therefore illuminating to explore the implementation rates of forums, the program format intended for adult-only groups. Forums were not adopted by a large portion of partner institutions implementing NISE Net activities. According to the 2010 *Delivery and Reach Study*, in-depth experiences, such as science cafés and forums, were rarely delivered by institutions during NanoDays. NanoDays 2010 reporting data shows that 11% of institutions reported delivering either science cafés or forums from the NanoDays kit (Table 6). The partner survey examining implementation over the course of a year shows that only 5% of Network institutions report implementing forums (Table 7).

Table 6. Frequency of use of NanoDays kit elements.

Kit Elements	Percent of Total (N=147)
Exploring activities	99%
Zoom interactive media	9%
Forums	8%
Decide nano game	8%
Science cafés	3%
Theater presentation	2%
None	1%

Note. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Table 7. Proportion of institutions that reported delivering NISE Network activities between July 2009 and June 2010.

Activity Type	Percent of Respondents (n=151)
Cart demonstrations & facilitated activities	81%
Exhibits, displays, and media	44%
Classroom activities	34%
Stage presentations and museum theater	14%
Forums	5%
None	11%

Note. Respondents indicated directly whether or not their institution had delivered any programs of each format. Program formats were later combined for analysis. Reprinted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

Therefore, as forums account for only a small portion of adults reached, and Network activity indicates that adults are being reached, it is probable that adults are being reached through the implementation of other activities. Network implementation of nano education activities reaching adult-only groups possibly does so through methods other than the method which was the focus of Network product development.

There is a significant portion of the partners who appear to not view adult-only groups as one of their institution's target audiences. This can be seen in the Site Visit data which examines the self-reported audiences of 26 partner institutions. Of the institutions who participated in the 2010 Site Visits, six of 26 institutions (23%) responded that adults are an audience with which they implement nano education activities (Table 4). This small percentage could also be a result of the range of institutions that were visited.

As the Network ended the fifth year of the grant, the Network began to focus on other program formats with an adult-only group focus, including science cafés and videos. For grant Years 6-10, the Forums working group has combined with the Programs working group in order to collaborate on the development of educational products, including programs and media. Future

analyses should examine this work as well as the extent to which all Network implementation sources target adult-only groups. As it is possible this audience is being reached through educational experiences other than those that the NISE Network has focused product development work on, this is an area in which Network product developers could gain insight from Network partners in planning future product development work. Exploring the full range of methods used by Network partners to reach adult-only groups could provide examples to Network product developers.

Finding 2: Younger children and out-of-school time program participants are audiences for which there is evidence of growing alignment between NISE Network educational product development and implementation.

Two audience categories, younger children and out-of-school time program participants, showed growing alignment between the audiences targeted through the Network's educational product development and dissemination and those audiences targeted through the implementation of nano education activities by Network partners. This alignment is identified as growing in order to highlight a shift in the priority of certain audiences within the Network over the first five years. As family groups and adult-only groups were targeted since the beginning, targeting other audience categories was a decision that was made later. As the Network has focused more on these audiences in Years 4 and 5 of the project, there is still additional work that could be done to bring the audiences into fuller alignment between development and implementation.

Younger children

Younger children as an audience category can have different meanings for different institutions. Children's museums often consider younger children to be less than five years of age. As the topic of nanotechnology is emerging and complex, individuals less than eight years of age have sometimes been considered part of this category.

Younger children have increasingly come to the forefront of Network implementation activities. However, although the Network has made efforts to support partners who reach younger audiences, partners continue to seek assistance in implementing nano education activities with younger children.

From the perspective of NISE Network development and dissemination, an emphasis on assisting partners in finding ways to incorporate nano programming geared toward younger audiences can be seen through many activities of the Network Community working group. This working group is not responsible for the development of Network products intended for the public, but seeks to support Network partners in their implementation of such products. It includes seven regional hubs across the United States as well as topical hubs – one of which is geared toward reaching children's museums. The Children's Museum Hub was developed in Year 4 to provide the Network with a children's museum contact within NISE Net. According to the Year 5 annual report, "The hub leaders act as conveners, hosts, and guides for the new partners, helping them find their way into the workings and resources of the NISE Net and pairing them with nano researchers and scientists" (NISE Network, 2010e, p. 6). The inclusion of a topical hub for children's museums shows a concerted effort to support NISE Net partners whose focus is on younger children through NISE Net community activities.

Other professional activities related to younger audiences include a session at the 2009 NISE Net Annual Meeting about engaging young children and the Network's continued presence at the Association of Children's Museums (ACM) annual conference. For example, during the 2010 ACM annual conference NISE Net Tier 1 and 2 partners presented during conference sessions, displayed a booth in the Exhibit Halls, and led a pre-conference workshop that introduced children's museum staffers to the concepts around nanoscale science, engineering, and technology as well as shared nano-related activities that are ideal in a children's museum setting. A subsequent workshop for the 2011 conference is also planned.

In terms of specific public products related to younger audiences, the introduction of the children's museum hub also brought with it individuals interested in creating products specifically for younger audiences. Several products were created in Years 4 and 5; two of these activities were included in the 2010 NanoDays kit.

In addition to the evidence that younger children is a focus of NISE Net product development and dissemination, there is also evidence that younger audiences are a focus for those organizations who implement NISE Net products. Audience appropriateness is mentioned during the 2010 Site Visits as well as in the *Delivery and Reach Study* as one of the reasons partners choose to implement a program. When asked during the Site Visit partner interview what makes them choose to implement one program over another, one partner said "[Programs] that hit our age group are important."[62] Another partner replied that younger audiences specifically impacted their product implementation saying, "One of the factors that affect us is that our audience for the most part is younger children so it's difficult to really get the idea across to those kids."

This importance of audience appropriateness has led many partner institutions to adapt current NISE Net educational products. As shown in the *Delivery and Reach Study*, many modifications that are being made involve adapting a program for younger audiences. When asked on the partner survey how they had modified NISE Network activities during Year 5, the second most common modification was "adapting for different audiences" (61%) (Table 8). When given the opportunity to describe any other changes, "the majority of respondents used this open-ended question to provide examples of the previously listed six modification categories... and "adapted for a different audience", was mentioned 13 times (17%). Adaptations were primarily made to accommodate young children, but were also made to accommodate language differences, older adults, and specific professions" (Pattison, et al., 2011). The fact that many partners appear to be modifying NISE Net products to be more appropriate for younger audiences suggests that there are potential improvements that could be made to NISE Net products in order to make them more appropriate for younger audiences. For this reason, younger audiences are listed as an area of growing, rather than existing, alignment between NISE Net development and dissemination, and partner implementation.

[62] Quotations from the 2010 Site Visits without corresponding citations are data that have not been written up in other NISE Network evaluation reports.

Table 8. Proportion of respondents indicating their institutions had modified Network products.

Modification type	Percent of Respondents
Incorporated into an existing program (*n*=141)	66.7%
Adapted for a different audience (*n*=137)	60.6%
Combined two or more programs or elements into a longer program (*n*=133)	53.4%
Adapted for different staffing needs (*n*=133)	45.1%
Changed the program format or type (*n*=135)	41.5%
Changed the educational messages (*n*=127)	15.7%

Note. Adapted from "2010 Delivery and Reach Study," by S. Pattison, M. Benne, and J. LeComte-Hinely, 2011.

It could be assumed that as the Network has involved more children's museums through its topical hub, modifications for younger audiences have increased. However, children's museums are not the only Network partners targeting younger children as an audience. The Site Visit data show examples of both children's museums and other types of museums reaching out to younger audiences. Half of the partners included in the Site Visits (50%) mentioned reaching younger audiences through nano education efforts. Of these 13 institutions, 6 were not children's museums. This is important because it provides an opportunity for the NISE Network to offer more support to all Network partners about effectively serving younger audiences. During the pre-conference workshop led by the NISE Net at the Association of Children's Museums annual conference, partners mentioned that they would be interested in learning more about how to engage their audiences with this topic. When answering the question about changes to future nano workshops for children's museum audiences, "close to half the suggestions were related to a desire for specific ideas and resources for working with young audiences" (Grack Nelson & Ostgaard, 2010a). However, given the fact that it is not only children's museums who are implementing nano programming with younger audiences, it is possible that any further ideas or resources could be of interest to a wide variety of Network partners.

Out-of-school time program participants

Out-of-school time program participants are groups of school-aged children participating in group programming often in the format of afterschool programs, camp-ins, and camps. These can be held at informal education institutions or offsite in collaboration with community-based organizations. While this program format can be implemented with school field trips to a museum, school groups are discussed at more length in the third section of this chapter.

Network partners have indicated that out-of-school time program participants, including programs held offsite in collaboration with community groups, are a target audience for their educational activities, and one through which they often reach a diverse audience. As Network partners expressed their interest in engaging the audience of children in peer groups through group programming, the NISE Network responded with the development and dissemination of such programs. Given that these Network activities began in later years of the Network, out-of-school time program participants appears to be an audience in which there is growing alignment between the implementation and development audiences of the Network.

Evaluation data provides insight into both partners' interests and implementation. However, programming with this audience is one instance in which many Network discussions have been framed around the topic of underserved audiences. Therefore the majority of partners' quotes explicitly discuss implementing group programming in order to reach underserved audiences. Although reaching out to underserved audiences is important to partners and the NISE Network, reaching underserved audiences is not the only reason for implementing programming with out-of-school time program participants.

Partners have reported implementing nano programming for children in peer groups in several analyses of Network-wide activity. Similar to younger audiences, findings from the 2010 *Delivery and Reach Study* suggest that partners are modifying or creating their own products intended to reach out-of-school audiences. This and the public impacts summative evaluation from grant Year 4 (Reich & Goss, 2009a) provide evidence that nano-focused classroom activities, which can include school groups and out-of-school groups, and camp programs are frequently being implemented by partner institutions. Although many programs created in Years 1-5 can be used for group experiences within the museum setting, there are very few products classified as "classroom activities" or "camp programs" in the NISE Net catalog.

2008-2009 Regional Workshop participants spoke of outreach to the institution's neighborhood or other parts of the state as well as engaging out-of-school program participants. One partner said, "[We] do outreach into community fairs and special events – groups that normally wouldn't come to the museum." Another noted that they implement "afterschool outreach at Boys and Girls Clubs for free." Engaging out-of-school groups was also mentioned by 3 institutions that participated in the 2010 Site Visits. One partner includes nano-related programming in camp programming saying, "I have a component in every girl or boy scout camp-in that I do." Another said, "At NanoDays, we have camps that come from the Y or police athletic league."

Partners indicated their interest in implementing nano programming intended for children in peer groups at both the 2008-2009 Regional Workshops and the 2009 Annual Meeting. In a post-survey to the 2008 and 2009 Regional Workshops, almost half of the participating professionals (48%) ranked that they were "very interested" in attending a future NISE Network-hosted workshop on the subject of nano in youth programs including afterschool and summer camps (Table 9).

Table 9. Partners' interest level in attending a workshop/session to learn more about the following topics.

	Not at all Interested	Somewhat Interested	Interested	Very Interested
Holding NanoDays at your institution (n=90)	3%	6%	23%	68%
Connecting nano to your programs (n=90)	3%	7%	28%	62%
Funding sources for nano activities (n=92)	4%	9%	28%	59%
Societal and ethical implications of nanotechnology (n=94)	1%	15%	30%	54%
Overview of various nano topics (n=92)	3%	10%	37%	50%
Nano in youth programs at your institution (after-school programs,	1%	15%	35%	48%

summer camps, etc.) (n=91)				
Marketing nano activities to public school audiences (n=92)	4%	11%	38%	47%
Developing a nano-literate floor and program staff (n=93)	7%	9%	40%	45%
Connecting nano to your exhibits (n=90)	4%	18%	34%	43%
Nano in formal education programs and resources (field trips, outreach, curriculum materials, etc.) (n=93)	4%	19%	38%	39%
Working with researchers and industry representatives to deliver nano programs and exhibits (n=93)	3%	22%	38%	38%
How to evaluate exhibits and programs (n=92)	7%	25%	34%	35%
Using the web to support community and share information (n=92)	3%	25%	41%	30%
Universal design of exhibits and programs (n=90)	11%	23%	36%	30%
Holding a nano forum at your institution (n=92)	11%	32%	32%	26%
Nano at children's museums (n=89)	16%	29%	19%	36%
Creating nano media – TV, film, web (n=93)	25%	36%	24%	16%

Note. Reprinted from "NISE Network Regional Workshops: Second Round of Workshops," by A. Grack Nelson, 2009.

Partners further expressed this interest during the 2009 Annual Meeting. One component of this meeting split up meeting attendees into groups organized by regional hubs. Daily discussion questions for these group sessions each had a different theme including: sharing what is going on in nano today; building stronger connections between scientists and individuals at ISE institutions; helping attendees think about how to integrate nano into topics and stories they already cover; and helping attendees think about how to integrate nano beyond their general audiences, specifically in relation to diversity, equity, and access issues. During both of the final discussions (integrating into existing topics and integrating beyond general audiences), the audience of out-of-school time program participants was discussed. First, Network partners reported that as they were already implementing programs intended for groups of children out of school, they were interested in knowing how to integrate the topic of nano into that program format. Also, in discussing how their work connected to NISE Net diversity, equity, and access efforts, Network partners reported being involved in partnerships with a wide variety of organizations made up of or serving underrepresented audiences. These include connections with schools (at all levels through graduate level), community organizations, professional organizations and those who implement afterschool programming. One participant stated they were reaching audiences by "working in a partnership with 4H to develop leadership youth institutes, regional computer/digital game" while another said they had a "partnership with YWCA".

In recognition of partners' efforts and interest in this area, NISE Net has developed products and practices aimed at improving partners' abilities to engage out-of-school time program participants in learning about nano. The work of the Diversity, Equity and Access working group

in Year 5 responded to the partners' previously existing activity in this area by forming a Partnership subgroup focused on forming and developing partnerships with community-based organizations and afterschool groups related to nano education. The goals of this work were to establish local partnerships between museums and community-based organizations, learn more about ways to establish effective and meaningful partnerships around the topic of nano, and document the group's process so that it can be shared with the broader Network (NISE Network, 2010e). The result of these efforts is the development of a *Partnership Guide* which outlines the steps and lessons learned as the Oregon Museum of Science and Industry and the New York Hall of Science formed partnerships and implemented activities with local Boys and Girls Clubs of America. When completed, this guide will be available as a tool to assist all Network partners in forming or continuing to implement this type of collaboration to engage this audience.

In addition to developing information about forming partnerships, NISE Net is also interested in providing Network partners with programs for implementation in a wider variety of these contexts. This increasing alignment between Network development and implementation suggests that there is more room to grow before the products available from the NISE Network meet the extent of the partners' needs for this audience.

Finding 3: Spanish-speaking audiences, people with disabilities, and school groups provide opportunities for alignment between NISE Network educational product development and implementation.

When examining the activity regarding audiences of the Network, three audience categories emerged that provide opportunities for future alignment between articulated audiences for NISE Net educational product development and partner implementation. These audiences include Spanish-speaking audiences, people with disabilities, and school groups. These opportunities exist because either the NISE Net has created a product that could engage an audience that is not being reached broadly by the museum field as a whole, such as Spanish-speaking audiences and people with disabilities, or because Network implementation has provided evidence of an audience that was not the focus of NISE Net development and dissemination activities, such as school groups.

As outlined above, Network audiences and the priority placed on them have shifted over the first five years. In addition to being responsive to partners, the NISE Network has also explicitly taken a stance on the inclusion of certain audiences in informal science learning. In an effort to push for the greater inclusion of some audiences who are traditionally underrepresented in science museums, including Spanish-speaking audiences and people with disabilities, NISE Net has focused on these audiences during the development of educational products and/or tools, guides and resources for the field.

Spanish-speaking audiences

Spanish-speaking audiences are those individuals for whom Spanish is their primary language. Over the first five years of the NISE Network, there was an initiative to develop products that could be used with Spanish-speaking audiences. Network partners seem to be interested in engaging this audience — as well as audiences who speak other languages that are not English — but although current evaluation efforts indicate that partners are interested in implementing nano programming with Spanish-speaking audiences, evaluation studies do not indicate widespread implementation of nano educational experiences with this audience to date.

In terms of Network products, the exhibits created by the Network in Years 2-3 included Spanish audio labels, and all exhibit videos and multimedia had both English and Spanish audio and subtitles. The introductory video created for the exhibit was widely distributed independently from the exhibits as well. The NISE Network Web team has created a specific page of the online catalog listing and linking to the Network products with Spanish translations available.

During Year 5, the Diversity, Equity and Access (DEA) working group focused on bilingual interpretation and created a subgroup focused on translation. Their goals included translating a representative set of NISE Net materials in Spanish for availability in the online catalog, collaborating with and advising NISE Net work groups when developing bilingual materials and products, and learning more about NISE Net partners' translation materials use and needs (NISE Network, 2010e). This work will also include the creation of a *Translation Process Guide* documenting NISE Net's translation process.

In terms of Network partners' implementation with Spanish-speaking audiences, the *Delivery and Reach Study* survey of partners cites "interest in this with less than half of individuals (43%) responding that they would be interested or very interested in Spanish translations." (Pattison, et al., 2011). Also, the 2008-2009 Regional Workshop and 2009 Annual Meeting participants list reaching diverse audiences with regard to language, even though not all are interested in Spanish. For example, when asked what resources they needed to increase efforts to bring nano to a diverse audience, one partner responded with an interest in "training opportunities on how to do sci ed for English language learners." Although many mentioned a bilingual context with English/Spanish audiences, other languages discussed include Mandarin, Japanese, and Korean. Further indication that Network partners could be interested in languages other than Spanish appears in the 2010 Site Visit data. Following one Site Visit, the NISE Net representative said, "Spanish isn't of particular interest to them, mostly because they work with English learners with a whole variety of first languages." Because Network partners seem to be interested in many languages in addition to Spanish, the *Translation Process Guide* could provide a valuable resource.

Network partners seem interested in implementing nano-related programming with a diverse audience in terms of language; however, there does not seem to be widespread implementation that has been documented with Spanish-speaking audiences. Two of 26 site visit institutions report Spanish-speaking audiences as one with which they implement nano programming. Although this could be attributable to the sites that were visited, similar information appears when examining data from all Network partners at the 2009 Annual Meeting. When asked what they were doing in their regions related to the NISE Net DEA efforts, 26 of 236 comments (11%) were related to audiences who speak languages other than English.[63]

As this is an audience the Network continues to develop products for, it will be important to examine Network-wide implementation in the future. The NanoDays 2011 report is investigating partners' use of the NanoDays translated materials, which may provide some important insights on the extent to which the translated products are currently being used during the implementation of NISE Net products with the public. Findings from this study may yield additional insights as to the extent of alignment between NISE Net development and dissemination, and partner implementation activities related to this audience.

[63] Meeting participants were able to offer more than one comment.

While the effort to generate greater understanding about ways to translate English-based educational experiences into other languages is noteworthy, in the end, there remain other options for supporting partners in reaching Spanish-speaking audiences. For example, the Network could decide to address other barriers that prevent museums from reaching this audience beyond the presence of multiple languages. In particular, the Network may need to heighten NISE Net partners' awareness of the need to reach this audience and of the presence of this audience in its existing and potential visitor population.

People with disabilities

People with disabilities are individuals who have a physical, sensory, intellectual, learning, or behavioral disabilities. The audience of people with disabilities emerged as another which has been included in NISE Network educational product development. However, the level of activity is not very extensive with this audience from a Network implementation standpoint. Similar to Spanish-speaking audiences, people with disabilities are traditionally underserved in science museums and the NISE Network product developers have sought to provide partners with resources that would assist with their inclusion.

The approach of universal design is the stance taken by the Network for product development and design. Universal design is defined as the "design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (NC State University, 2008). Products created within a universal design framework are intended for use by all visitors, including people with and without disabilities. The use of a universal design framework in museums has been shown to lead to both greater inclusion of people with disabilities as well as improved experiences for people without disabilities (Davidson, Heald, & Hein, 1991; Reich, Price, Rubin, & Steiner, 2010).

This emphasis on universal design is evident in the exhibits and programs developed by the NISE Net as well as in the tools and guides that inform others of this creation process. Documentation of this development process began with the formative evaluation of products that shows how the NISE Network Exhibits group and Programs group included people with disabilities in the creation of their products. Accessibility consultants were invited to review exhibits and programs created by the NISE Net. Results of one of these studies suggest that three elements appeared to be essential when considering the accessibility of NISE net exhibits and programs: the inclusion of tactile and hands-on experiences, the physical accessibility of the exhibit design (which includes the layout, the manipulative devices, and the exhibit heights), and audio descriptions (Reich, 2007).

The NISE Network used this and other information to create the documents entitled *Universal Design Guidelines for Exhibits* and *Universal Design Guidelines for Programs*. These tools "lay out some basic concepts and guidelines to begin a discussion among the partners about the best way to achieve the universal design of [products]" (NISE Network, 2010d, p. 1). It is the goal that these guidelines will make exhibits and programs more physically, cognitively, and socially inclusive. The *Universal Design Guidelines for Programs* were developed through a design charrette held at the Museum of Science, Boston on December 6-7, 2007. As described on page 2 of the Guidelines,

> *During this charrette, four experts from the field of universal design who have disabilities worked together with 20 museum professionals representing six museums to revise and refine four public programs (including stage demonstrations,*

interpretation carts, and a science theater play) to make these programs more inclusive of visitors with disabilities.

Further evidence of the Network's inclusion of people with disabilities is the use of these guidelines. NISE Network product developers strive to include aspects of universal design in the creation of all products. As shown in the catalog portion of the NISE Net website (www.nisenet.org), each product cites whether, and how, it reflects the principles of universal design in its design. For example, the *Wheel of the Future* program lists "provide multiple entry points and multiple ways of engagement" as its universal design component. Other ways in which programs are described as accessible include "repeat and reinforce main ideas and concepts" as well as "provide physical and sensory access to all aspects of the program."

Although the NISE Net has developed products that are guided by universal design principles, produced guiding tools, and disseminated the information in the created product description, there is little evidence that Network partners feel they are reaching people with disabilities through their nano education efforts. Only one of the 26 institutions visited through the 2010 Site Visits mentioned people with disabilities as part of their audience. Of the 2008-2009 Regional Workshop participants, only six of 88 institutions mentioned reaching people with disabilities over the course of seven workshops. When asked at the 2009 Annual Meeting how they were impacting the DEA-related efforts of NISE Net, the lowest number of responses included aspects related to universal design or access for people with disabilities.

The fact that the Network partners have not readily mentioned people with disabilities as a target audience does not necessarily mean that NISE Net's efforts related to universal design have not been fruitful. As stated above, universal design can lead to improved experiences for visitors without disabilities as well as visitors with disabilities. In addition, Network partners may be reaching people with disabilities without even realizing it. Currently, one in five individuals in the United States has a disability (Waldrop & Stern, 2003) and studies of museums across the country have shown that people with disabilities are part of the general museum-visiting population. Many museums may not know that they are currently serving people with disabilities as museums do not collect demographic information about disabilities, and many disabilities are not visible or apparent without asking the individual. This means it may be possible that NISE Net is reaching people with disabilities through its universally designed products, particularly its exhibition.

The idea that Network partners may not consider people with disabilities as a target audience does suggest, however, that the Network partners may not be announcing to their audience that these experiences are inclusive of a broad range of abilities and disabilities. If Network partners include a program's universal design features but do not highlight them in their communication with visitors (through access guides, the institution's website, or other forms of communication), visitors with disabilities may not know that the experiences are inclusive and may not participate in them during a visit to the institution.

School groups

School groups consist of a group of children participating in a program led by an informal education institution. School groups can be reached through field trips to an institution or through outreach to a school. Network partner institutions have reported implementing nano-related programming intended for school groups many times which has led the NISE Network to examine its position on the subject of school groups that museums reach in informal educational contexts.

Since the beginning of the grant, the NISE Network has not focused on engaging audiences within the formal education sector as the funding from the National Science Foundation is intended for the purposes of informal science education. There have been many discussions over the years to ensure that partners' needs are being met in a manner that aligns with the Network's overall mission. Although this remains true, school groups who visit NISE Network institutions as well as those who are visited by NISE Network institutions are an audience that Network partners intend to reach through their nano education efforts.

Much of the data collected by the Network in the first five years discussing implementation with school groups mentions the fact that this audience is often one though which institutions attempt to reach underserved audiences. However reaching underserved audiences is not the only reason that school groups are targeted as an audience.

Regional Workshop participants report that one way they reach underserved audiences is through their local schools. This includes the groups who visit NISE Net institutions as part of field trips as well as the groups who are part of programs that NISE Net museums and universities conduct as outreach in the schools themselves. Participants at the 2009 Annual Meeting mentioned schools as a way they reach diverse audiences, listing the following as some of the strategies the institutions employ: "lunch time programs at Title One schools" as well as "bringing outreach programs and career day presentations to local inner-city schools." It is important to remember, however, that these comments reflect ways NISE Net partner institutions are reaching diverse audiences across all content areas, and are not always specific to educational activities related to nano.

Data collected through the 2010 Site Visits demonstrate that school groups are an identified audience for the nano programming that is taking place within NISE Net partner institutions. These data reveal that half of the sites visited are engaging school groups with nano-related programming within their institution (13 of 26 sites, 50%), while almost one-quarter of the sites visited are engaging school groups with nano-related programming through outreach (6 of 26 sites, 23%).

In the future, there may be greater alignment between NISE Net development and implementation related to school groups as NISE Net has already discussed ways to include this audience within the context of an informal education setting. According to communication with Network leadership, some of the work of Years 6-10 will focus on developing programs for school groups in informal learning contexts, including school groups who visit museums on a field trip. This allows Network development to reach a key audience of its partners and support their efforts to integrate nano-related programming, while staying focused on informal science education. The Network does not plan on developing a formal curriculum for formal education contexts. Partners are of course welcome to use NISE Net products for those audiences, but development and dissemination efforts will remain within the context of informal science education.

Conclusion

The *Reaching Public Audiences* chapter of the NISE Net Public Impacts Summative Evaluation *Review of NISE Network Evaluation Findings: Years 1-5* examines the public audiences of NISE Network development and dissemination as well as the public audiences of the broader NISE Network partners in an effort to examine where there is existing or growing alignment between these efforts as well as outline opportunities for future alignment. Because it is the goal of this chapter to look at the differences and similarities between these audiences, some sources are more internally-focused and include information about the *development and dissemination* of NISE Network products while other sources are broader and capture information about the *implementation* of NISE Net products.

Family groups and adult-only groups are audiences for which there is evidence of alignment between Network development and implementation, despite the fact that this alignment is slightly different for these two group types. The audience of family groups was included as an audience of Network development since the beginning of the grant as it was determined to be an integral audience to most informal science education settings. The audience of adult-only groups was also included in the product development of the Network since Year 1, yet Network implementation sources appear to be reaching this audience through nano educational programming in ways other than the format that was the Network's focus.

Younger children and out-of-school time program participants are audiences for which there is evidence of growing alignment between Network development and implementation. The shift in importance of these audiences and the fact that they have risen in priority in terms of product development suggest that NISE Net is responding to partners. This is an area where there is a potential for greater alignment within a short period of time.

Audiences for which there are opportunities for greater future alignment between Network development and implementation include Spanish-speaking audiences, people with disabilities, and school groups. In many cases, the opportunities for future alignment reflect a specific stance that NISE Net has taken to promote greater inclusion of certain audiences in informal science learning. NISE Net development sources sought to create products and processes that Network partners could use to engage these audiences. While generating new knowledge and understandings of how to reach these audiences was an important first step. Moving forward, the Network may also want to consider ways to increase the Network partners' sense of importance for reaching or awareness of these audiences. In the case of school groups, the push is in the opposite direction; Tier 2 partners currently implement nano-related programming in a setting that NISE Net development efforts cannot reach. NISE Net has met the challenge of deciding its stance on school groups but will continue to support partners' needs as much as possible.

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Appendix A. NISE Network Educational Products

PROGRAMS

Facilitated Activities

Facilitated activities are brief, hands-on experiences for small groups of visitors. They typically last around five minutes, and can be presented in a variety of spaces, including exhibit galleries, demonstration areas, and classrooms. Facilitated activities are usually designed for the general public, targeting families and other social groups that frequently visit science museums. Learning objectives vary, but these activities often address basic science content related to nanoscale science, engineering, and technology, especially related to ideas 1, 2, and 3 of the NISE Net Content Map. Due to their brief length, the activities generally have only one or two focused learning objectives.

Cart Demonstrations

Cart demonstrations are interactive programs for a small group of visitors. They typically last around 10 minutes, and are often presented at a cart, table, or dedicated demonstration space in an exhibit gallery. Cart demonstrations are usually designed for the general public, targeting families and other social groups that frequently visit science museums. Learning objectives vary, but cart demonstrations may address one or more of the four big ideas of the NISE Net Content Map.

Stage Presentations

Stage presentations are public programs for a large group of visitors. They typically last around 20 minutes, and are often delivered in a dedicated presentation area or stage. Stage presentations are usually designed for the general public, targeting families and other social groups that frequently visit science museums. Learning objectives vary, but stage presentations may address one or more of the four big ideas of the NISE Net Content Map.

Science and Museum Theater

Science and museum theater includes theatrical plays and other performances for a large group of visitors. They typically last around 15 minutes, and are often delivered in a dedicated presentation area or stage. Museum theater performances are often designed for the general public, targeting families and other social groups that frequently visit science museums. Learning objectives vary, but performances may address one or more of the four big ideas of the NISE Net Content Map.

Classroom Activities

Classroom activities include workshops, labs, and lessons for student groups. They are typically presented in a dedicated classroom or lab space. Length of time can vary from 45 minutes for an elementary field trip program to several hours or days for labs, summer camps, and other program formats. Classroom activities typically target specific grade or age ranges. Learning objectives are appropriate for the target audience, and may address one or more of the four big

ideas of the NISE Net Content Map. Additionally, learning objectives for classroom activities are often developed with consideration to state or national educational standards.

Forums

Forums are a special type of programming that encourages audience consideration of the societal and ethical implications of nanoscale science and technology, or big idea 4 of the NISE Net Content Map. Older youth and adults participate in one- to two-hour facilitated discussions that promote exploration and foster dialogue and deliberation of the perceived risks and benefits of nanoscale science, engineering, and technology. Forums programs can take place in a variety of contexts, including science museums, libraries, community centers, and schools.

EXHIBITS

Exhibits

Exhibits may take many formats, including hands-on interactive components, multimedia components, object displays, and graphic panels, or some combination of these elements. Exhibits typically are unstaffed experiences, targeting families and other social groups that frequently visit science museums. Learning objectives vary, but exhibits may address one or more of the four big ideas of the NISE Net Content Map. A group of exhibits organized around a theme makes up an exhibition.

Portable Exhibits

Portable exhibits are relatively small, moveable exhibit components. They typically are unstaffed experiences, and may take many formats, including hands-on interactive components, multimedia components, object displays, graphic panels, or some combination of these elements. Portable exhibits are typically used for off-site outreach efforts, reaching families, students, and other groups. Learning objectives vary, but exhibits may address one or more of the four big ideas of the NISE Net Content Map. A group of exhibits organized around a theme makes up an exhibition.

Traveling Exhibitions

Traveling exhibitions are a group of exhibits displayed in museums or similar venues on a temporary basis, through a loan or rental agreement with the owner. Exhibitions are made up of a number of individual exhibits, usually organized around a theme. They can include hands-on interactive components, multimedia components, object displays, and graphic panels. Exhibitions typically are unstaffed visitor experiences, targeting families and other social groups that frequently visit museums. (They are frequently accompanied by related programming, providing related staffed visitor experiences.) Learning objectives vary, but exhibitions may address one or more of the four big ideas of the NISE Net Content Map.

Permanent Exhibitions

Permanent exhibitions are a group of exhibits, usually organized around a theme, that are installed in museums or similar venues on a long-term basis. Exhibitions are made up of a number of individual exhibits, including hands-on interactive components, multimedia components, object displays, and graphic panels. Exhibitions typically are unstaffed visitor

experiences, targeting families and other social groups that frequently visit science museums. (They are frequently accompanied by related programming, providing related staffed visitor experiences.) Learning objectives vary, but exhibitions may address one or more of the four big ideas of the NISE Net Content Map.

MEDIA

Audio/Podcast

Podcasts are pre-recorded programs that can be downloaded and played on digital media players. Although podcasts primarily include audio content, they may also include images and video. Podcasts range in time from a minute to an hour. Individual podcasts may be organized around themes, and related to other visitor experiences (such as exhibitions). Podcasts can be designed for the general public or can target specific audiences. Learning objectives vary, but podcasts may address one or more of the four big ideas of the NISE Net Content Map.

Digital Images and Graphics

Digital images and graphics include still images and interactive media products that can be downloaded and printed out or played on computers. Individual digital images and graphics may be incorporated into other visitor experiences (such as exhibits). Digital images and graphics can be designed for the general public or can target specific audiences. Learning objectives vary, but digital media may address one or more of the four big ideas of the NISE Net Content Map.

Online Games and Activities

Online games and activities include interactive multimedia experiences that can be played over the Internet. They may also be incorporated into other visitor experiences (such as exhibits). Learning objectives vary, but online games and activities may address one or more of the four big ideas of the NISE Net Content Map.

Print Media

Print media include books, posters, banners, and other products that can be downloaded and printed out or presented on electronic displays. Individual print media products may be incorporated into other visitor experiences (such as exhibits). Learning objectives vary, but print media may address one or more of the four big ideas of the NISE Net Content Map.

Video

Videos include standalone products, as well as audiovisual clips and complete videos that are incorporated into other visitor experiences (such as exhibits). Videos can be designed for the general public, or can target specific audiences. Learning objectives vary, but videos may address one or more of the four big ideas of the NISE Net Content Map.

Website

Websites include collections of web pages with a variety of different digital products, including text, images, graphics, videos, online games and activities, databases, and many other resources.

Websites may be standalone products, may be intended to support other educational products by providing additional information, or may be incorporated into other visitor experiences (such as exhibitions). Websites can be designed for the general public, or they can target specific public or professional audiences. Learning objectives vary, but websites may address one or more of the four big ideas of the NISE Net Content Map.

Image Collection

The image collection is a library of digital scientific images related to nanoscale science, engineering, and technology. The images are not intended as educational products for the public per se, but they may be incorporated into other visitor experiences (such as programs and exhibits).

Appendix B. NISE Network Evaluation Reports

Table B1. Reports written by the NISE Network Evaluation working group 2005-2010 organized by grant Year. [64]

Year	Title	Author
2005	Compilation of Nanoscale Communication Projects: Part IIA of Front-End	Barbara Flagg
2005	Compilation of Nanoscale Communication Projects: Part IIB of front end	Barbara Flagg
2005	Nanotechnology and the Public: Part I Appendix	Barbara Flagg
2005	Nanotechnology and the Public: Part I of Front-End	Barbara Flagg
2006	Biobarcodes Demonstration -- Formative Evaluation	Amy Grack Nelson and Jane Miller
2006	Cancer Detection and Treatment -- Formative Evaluation	Denise Huynh
2006	Carbon Nanotubes and Electrical Transmission Activity -- Formative Evaluation	Kirsten Ellenbogen
2006	Detecting Lead with Gold Nanoparticles--Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Exploratorium Round 3 Forum Results	Christine Reich
2006	Exploring Properties -- Surface Area--Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2006	Exploring Tools - Scanning Probe Microscopy--Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2006	Fact or Fiction -- Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2006	Feeling Matter -- Tools of the Trade -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Forms of Carbon -- Formative Evaluation	Sarah Cohn
2006	Forms of Carbon Demonstration Formative Evaluation	Scott Van Cleave
2006	Gold Nanoshells: Tuned to Absorb Infrared Light--Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Hints of a Smaller World -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Hints of a Smaller World Formative	Josh Gutwill
2006	Lotus Leaf Effect - Exploratorium--Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2006	MOS-NISE Prototyping Summary	Elissa Chin
2006	Museum of Science, Boston Round 3 Forum Results	Christine Reich
2006	Nano Factory -- Formative Evaluation (Aug 2006)	Denise Huynh
2006	Nano Factory -- Formative Evaluation (July 2006)	Denise Huynh
2006	Nano Science Buzz -- Formative Evaluation	Al Onkka and Kirsten Ellenbogen
2006	Nano Silver Bullet	SMM
2006	Nano Silver Bullets 1 -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh

[64] Reports not listing specific authors are identified by institution.

Year	Title	Author
2006	Nano Silver Bullets 2 -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Nano Tabletops -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Nano Theater Immersive -- Formative Evaluation	Sarah Cohn
2006	Nano Theater Storyline -- Formative Evaluation	SMM
2006	NanoLab -- Formative Evaluation	Amy Grack Nelson and Kirsten Ellenbogen
2006	Nanolab Exhibit--Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Nanoscience Exhibition Prototyping -- Formative Evaluation	Scott Van Cleave
2006	Nanotechnology Cancer Treatments -- Formative Evaluation	Denise Huynh
2006	Nanotechnology Forum Marketing Materials	Christine Reich
2006	NISE Exhibits	Kirsten Ellenbogen
2006	NISE Exhibits & Programs--Workshop Participant Evaluation	Denise Huynh
2006	NISE Exhibits and Programs Marketing Survey -- Formative Evaluation	Amy Grack Nelson and Kirsten Ellenbogen
2006	NISE Exhibits Workshop Participant Evaluation	Scott Van Cleave and Amy Grack Nelson
2006	NISE Nanotechnology Forums Phase 1, Round 1. Forum Results	Christine Reich
2006	NISE Net Forum Round 1 Formative Evaluation Preliminary Findings	Christine Reich
2006	North Carolina Museum of Life and Science Nanotechnology Forum Formative Results	Christine Reich
2006	Nucleation Immersive Digital Interactive--Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Nucleation Video Interactive -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	OMSI Round 3 Forum Results	Christine Reich
2006	OMSI Tabletop Exhibition Prototype	OMSI
2006	Risks and Benefits -- Formative Evaluation	Denise Huynh
2006	Science Buzz--Formative Evaluation	Kirsten Ellenbogen
2006	See a World in Sand -- Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	SMM Round 2 Forum Results	Christine Reich
2006	Space Elevator -- Formative Evaluation	Denise Huynh
2006	Space Elevator -- Formative Evaluation	Denise Huynh and Sarah Cohn
2006	Surface and Volume Issues - MOS--Formative Evaluation	Kirsten Ellenbogen and Denise Huynh
2006	Three Drops - Exploratorium--Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2006	Treating Disease--Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2006	Wheel of the Future Demonstration Report -- Formative Evaluation	Amy Grack Nelson
2006	Workshop Professional Feedback Report: Aerogel Program -- Professional Review	Al Onkka

Year	Title	Author
2006	Workshop Professional Feedback Report: Detecting Lead -- Professional Review	SMM
2006	Workshop Professional Feedback Report: Gold Nanoshells and Cancer -- Professional Review	SMM
2006	Workshop Professional Feedback Report: Gold Nanoshells and Infrared Light -- Professional Review	SMM
2006	Workshop Professional Feedback Report: Nanolab -- Professional Review	SMM
2006	Workshop Professional Feedback Report: Nucleation--Grow Your Own Crystals -- Professional Review	SMM/Scott Van Cleave
2006	Workshop Professional Feedback Report: Science Buzz -- Professional Review	SMM
2006	Workshop Professional Feedback Report: Surface Area -- Professional Review	SMM
2006	Workshop Professional Review Report: Biobarcoding -- Professional Review	Denise Huynh
2006	Workshop Professional Review Report: Blue Whale and Nanodot -- Professional Review	SMM
2006	Workshop Professional Review Report: Cancer Detection and Treatment--Professional Review	SMM
2006	Workshop Professional Review Report: Carbon Nanotubes -- Professional Review	Denise Huynh
2006	Workshop Professional Review Report: Forms of Carbon -- Professional Review	Denise Huynh
2006	Workshop Professional Review Report: Inkjet Printer -- Professional Review	Denise Huynh
2006	Workshop Professional Review Report: Liquid Crystals -- Professional Review	Denise Huynh
2006	Workshop Professional Review Report: Lotus Leaf Effect -- Professional Review	SMM
2006	Workshop Professional Review Report: Risks and Benefits of Nano -- Professional Review	Denise Huynh
2006	Workshop Professional Review Report: Scanning Probe Microscopy -- Professional Review	SMM
2006	Workshop Professional Review Report: Three Scales of Water -- Professional Review	SMM
2006	World of Carbon Nanotubes -- Formative Evaluation	Al Onkka and Amy Grack Nelson
2007	100 Partners' Workshops -- Formative Evaluation	Amy Grack Nelson and Sarah Cohn
2007	Crystals -- Formative Evaluation	Kirsten Ellenbogen
2007	Crystals and 3 Drops Immersive Prototypes -- Formative Evaluation	Sarah Cohn and Denise Huynh
2007	Cutting It Down to Nano -- Formative Evaluation	Sarah Cohn and Amy Grack Nelson
2007	Cutting It Down to Nano -- Formative Evaluation	Amy Grack Nelson
2007	Energy and Environment Package -- Formative Evaluation	Kirsten Ellenbogen
2007	Exhibit Package Prototypes -- Formative Evaluation	Amy Grack Nelson and Murphy Pizza

Year	Title	Author
2007	Exploratorium and Museum of Science Communal Forum Results	Elizabeth Kunz Kollmann
2007	Exploring Properties -- Surface Area -- Formative Evaluation	Amy Grack Nelson
2007	Forms of Carbon Expo -- Formative Evaluation	Sarah Cohn
2007	Illustrations - Human Bloodstream and Butterfly	Joyce Ma
2007	Intro to Nano, Nano Medicine, and NanoLab -- Formative Evaluation	Kirsten Ellenbogen and Al Onkka
2007	Intro to Nanotechnology -- Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2007	Ithaca Sciencenter: NanoLab Report -- Formative Evaluation	Kirsten Ellenbogen
2007	July 2007 Nano Family Forum -- Formative Evaluation	Amy Grack Nelson and Sarah Cohn
2007	Keep Clean Demonstration -- Formative Evaluation	Amy Grack Nelson
2007	Lotus Effect -- Formative Evaluation	Sarah Cohn
2007	Magic Sand -- Formative Evaluation	Sarah Cohn
2007	Museum of Science Communal Forum 2.2 Results	Elizabeth Kunz Kollmann
2007	Nano Comedy -- Formative Evaluation	Denise Huynh and Amy Grack Nelson
2007	Nano Energy and Environment Prototype -- Workshop Participant Feedback	Denise Huynh
2007	Nano Forum: School Setting -- Formative Evaluation	Sarah Cohn and Amy Grack Nelson
2007	Nanolab -- Formative Evaluation	Kirsten Ellenbogen and Al Onkka
2007	NanoLab and Nanomedicine -- Formative Evaluation	Kirsten Ellenbogen and Al Onkka
2007	Nanomedicine -- Formative Evaluation	Kirsten Ellenbogen and Al Onkka
2007	Nanomedicine and Intro to Nanotechnology -- Formative Evaluation	Kirsten Ellenbogen and Jane Miller
2007	Nanomedicine Multimedia Component -- Formative Evaluation	Amy Grack Nelson
2007	Nanomembranes and Water Filtration -- Formative Evaluation	Kirsten Ellenbogen
2007	Nanotechnology and Energy -- Formative Evaluation	Amy Grack Nelson
2007	Nanotechnology Onstage at the Museum of Science: Presentation review	Elissa Chin and Elizabeth Kunz Kollmann with Barbara Flagg
2007	NCMLS Communal Forum Results	Elizabeth Kunz Kollmann and Christine Reich
2007	NISE Network Accessibility Walk-through Summary of Findings	Christine Reich
2007	NISE Program Group Workshop -- Participant Evaluation	Amy Grack Nelson
2007	NISE Program Workshop -- Post Workshop Survey Results	Amy Grack Nelson and Sarah Cohn
2007	NISE Programs: Universal Design Charrette -- Post-Meeting Survey Report	Amy Grack Nelson and Murphy Pizza
2007	NISE Year 1 Forums: A Review. Preliminary Formative Evaluation Findings	Christine Reich
2007	OMSI Communal Forum Results	Elizabeth Kunz Kollmann
2007	Scale Ladders - Communicating Size and Scale	Joyce Ma

Year	Title	Author
2007	Self-Assembly Demonstration -- Formative Evaluation	Amy Grack Nelson
2007	Small Balloons Models -- Formative Evaluation	SMM/Denise Huynh
2007	Small Science: Updates in Nanotechnology Research -- Formative Evaluation	Sarah Cohn
2007	Small Things with Big Benefits and Big Risks -- Formative Evaluation	Amy Grack Nelson
2007	SMM Communal Forum Results	Elizabeth Kunz Kollmann
2007	SMM's Wheel of the Future Program -- Formative Evaluation	Amy Grack Nelson
2007	Stained Glass Workshop -- Formative Evaluation	Denise Huynh
2007	Three Drops -- Formative Evaluation	Kirsten Ellenbogen
2007	Visitors' Drawings of Small	Joyce Ma
2007	Workshop Professional Feedback Report: Advances in Energy -- Professional Review	Denise Huynh
2007	Workshop Professional Feedback Report: Nano Medicine -- Professional Review	Denise Huynh
2007	Workshop Professional Feedback Report: Small Game Hunter -- Professional Review	Denise Huynh
2007	Workshop Professional Feedback Report: Snowflakes -- Professional Review	SMM
2007	Workshop Professional Feedback Report: Surface Area Program -- Professional Review	SMM
2007	Workshop Professional Feedback Report: Three Scales of Water -- Professional Review	SMM
2007	Workshop Professional Feedback Report: Wheel of the Future -- Professional Review	SMM
2007	Workshop Professional Review Report: Introduction to Nano -- Professional Review	Denise Huynh
2007	Workshop Professional Review Report: Nano Lab -- Professional Review	Denise Huynh
2008	2008 NanoDays -- Participating Organizations Evaluation	Scott Van Cleave, Murphy Pizza, and Sarah Cohn
2008	Aerogel -- Formative Evaluation	Sarah Cohn and Amy Grack Nelson
2008	ASTC Forum Workshop Evaluation -- Formative Evaluation	Amy Grack Nelson and Elizabeth LaPorte
2008	Balloon Nanotubes -- Formative Evaluation	Claire Philippe and Sarah Cohn
2008	Bump and Roll Exhibit -- Formative Evaluation	Jane Miller and Sarah Cohn
2008	Changing Colors -- Formative Evaluation	Jane Miller and Sarah Cohn
2008	DNA: Exploring Nanostructures - Formative	Sarah Cohn and Claire Philippe
2008	DNA: Exploring Nanostructures Report 2 - Formative	Elizabeth LaPorte and Sarah Cohn
2008	Exploratorium Communal Forum Results	Elizabeth Kunz Kollmann
2008	Exploring Forces -- Gravity -- Formative Evaluation	Claire Philippe and Sarah Cohn
2008	Exploring Forces: Gravity - Formative	Elizabeth LaPorte and Sarah Cohn
2008	Exploring Materials -- Liquid Crystals -- Formative Evaluation	Claire Philippe and Sarah Cohn
2008	Exploring Materials: Ferrofluid - Formative	Elizabeth LaPorte
2008	Exploring Materials: Ferrofluid -- Formative Evaluation	Murphy Pizza and Sarah Cohn

Year	Title	Author
2008	Exploring Materials: Nano Fabrics	Al Onkka
2008	Exploring Measurement -- Ruler -- Formative Evaluation	Claire Philippe and Sarah Cohn
2008	Exploring Measurement: Human Body - Formative	Elizabeth LaPorte and Sarah Cohn
2008	Exploring Measurement: Solutions - Formative	Elizabeth LaPorte and Sarah Cohn
2008	Exploring Properties -- Surface Area - Formative Evaluation	Murphy Pizza and Sarah Cohn
2008	Exploring Properties -- Surface Area -- Formative Evaluation	Sarah Cohn
2008	Exploring structure: Buckyball activity- formative evaluation	Sarah Cohn and Elizabeth LaPorte
2008	Exploring Tools -- SPM -- Formative Evaluation	Elizabeth LaPorte and Sarah Cohn
2008	Fact or Fiction -- Formative Evaluation	Kirsten Ellenbogen and Claire Philippe
2008	Illustration - Zoom into a Butterfly	Joyce Ma
2008	Inkjet Printer -- Formative Evaluation	Sarah Cohn and Amy Grack Nelson
2008	Introduction to Nano -- Formative Evaluation	Sarah Cohn and Claire Philippe
2008	Magic Sand Program -- Formative Evaluation	Denise Huynh
2008	Museum of Science Communal Forum 3.1 Results	Elizabeth Kunz Kollmann
2008	Museum of Science Forum 3.3 Results	Elizabeth Kunz Kollmann
2008	Museum of Science, OMSI, and MLS April Communal Forum Results	Elizabeth Kunz Kollmann
2008	Museum of Science's Nano 101 Program -- Formative Evaluation	Murphy Pizza and Amy Grack Nelson
2008	Nano Dreams and Nano Nightmares -- Formative Evaluation	Amy Grack Nelson and Sarah Cohn
2008	Nano Intro Cart Program -- Formative Evaluation	Jane Miller and Amy Grack Nelson
2008	NanoBooks: "How Small Is Nano?" & "Is That Robot Real?" -- Formative Evaluation	Jane Miller and Sarah Cohn
2008	Nanobots -- Formative Evaluation	Claire Philippe and Amy Grack Nelson
2008	NanoLab -- Formative Evaluation	Claire Philippe and Kirsten Ellenbogen
2008	NanoRobots -- Formative Evaluation	Amy Grack Nelson
2008	Nanotechnology and Alternative Energy Front-end Museum of Science Results	Elizabeth Kunz Kollmann
2008	NISE Network Regional Workshops: Round One 2008	Amy Grack Nelson and Claire Philippe
2008	NISE Network Regional Workshops: Round One 2008 - Workshop Logistics Formative Evaluation	Amy Grack Nelson and Claire Phillipe
2008	NISE Program Workshop: Post-Workshop Survey Results	Amy Grack Nelson and Elizabeth LaPorte
2008	Piezoelectricity -- Formative Evaluation	Sarah Cohn and Amy Grack Nelson
2008	Program Kit Evaluation -- Process of Receiving Kits	Amy Grack Nelson

Year	Title	Author
2008	Public Engagement Planning Meeting 2008: Post-Workshop Evaluation Report	Amy Grack Nelson
2008	Regional Workshop Post-Survey Data on nisenet.org and the Catalog	Amy Grack Nelson and Claire Philippe
2008	Shaky, Sticky, Bumpy -- Formative Evaluation	Denise Huynh
2008	Sizing Things Down -- Formative Evaluation	David Ordos and Amy Grack Nelson
2008	SMM and ASTC Privacy Forum Results	Elizabeth Kunz Kollmann
2008	SMM Communal Forum Results	Elizabeth Kunz Kollmann
2008	SMM's Nano Camp -- Formative Evaluation	Amy Grack Nelson
2008	Stained Glass -- Formative Evaluation	Denise Huynh
2008	Summative Evaluation of Awareness of Nanotechnology by the Museum Public	Barbara Flagg
2008	Summative Evaluation of NISE Network's Public Forum: Nanotechnology in Health Care	Barbara Flagg
2008	Surface Area Kit -- Formative Evaluation	Amy Grack Nelson
2008	Three Drops	Joyce Ma
2008	Universal Design Guidelines -- Review Results	Denise Huynh and Amy Grack Nelson
2008	UW-MRSEC's Nano 101 Program -- Formative Evaluation	Murphy Pizza and Amy Grack Nelson
2008	Visitors' Interpretations of Images of the Nanoscale	Joyce Ma
2008	Visualization Laboratory - Formative Evaluation. Spiral Zoom on a Human Hand	Joyce Ma
2008	Wheel of the Future - Pilot Testing	Amy Grack Nelson
2008	World of Carbon Nanotubes -- Pilot Testing Results	Amy Grack Nelson
2009	"Computing the Future" Stage Presentation formative	Kerry Bronnenkant
2009	"Treating Tumors with Gold" Stage Presentation formative evaluation	Elizabeth Kunz Kollmann
2009	Attack of the Nanoscientist -- Formative Evaluation	Denise Huynh
2009	Diffusion	Andrea Motto and Eric Siegel
2009	Exhibit & Program Summative Evaluation -- Year 4 Progress Report	Al Onkka, Sarah Cohn, and Kirsten Ellenbogen
2009	Exploring Measurement - Stretchability	Scott Van Cleave and Al Onkka
2009	Exploring Measurement: Molecule	KC Miller
2009	Flying Cars version 1	Anders Liljeholm
2009	Flying Cars version 2	Anders Liljeholm
2009	Flying Cars version 3	Anders Liljeholm
2009	Impact of Television Presentation Formats on Understanding *DragonflyTV Nano* Content	Barbara Flagg
2009	Inverness - Field Study	Inverness
2009	Inverness - Interview Study with Scientists	Inverness
2009	Inverness - Interview Summary with Hub Leaders	Inverness
2009	Inverness - Overview of the NISE Network	Inverness
2009	Inverness - Reach and Impact Study	Inverness
2009	Inverness - Summary of Interviews with Regional Workshop Participants	Inverness

Year	Title	Author
2009	Inverness - Vignettes: Stories of Institutions Engaged with NISE Net	Inverness
2009	Museum of Science Forum 4.1 Results	Elizabeth Kunz Kollmann
2009	NanoDays 2009 Kit Evaluation	Sarah Cohn and Al Onkka
2009	Nanomedicine Explorer Interactive Multimedia Kiosk	Kerry Bronnenkant
2009	Nanoscale Education Outreach Evaluation	Scott Ewing
2009	NISE Net Public Impacts Summative Evaluation: Pilot Nanoawareness Study, Year 4 Report	Brett Kiser and Marcie Benne
2009	NISE Network Annual Meeting: Attendee Survey	Amy Grack Nelson, Gina Svarovsky, Scott Van Cleave, and Kathleen Miller
2009	NISE Network Annual Meeting: Subawardee Survey	Amy Grack Nelson, Kathleen Miller, and Scott Van Cleave
2009	NISE Network Diversity Workshop 2009 Post-Workshop Evaluation Report	Anna Lindgren-Streicher
2009	NISE Network Forum: "Risks, Benefits, and Who Decides?"	Elizabeth Kunz Kollmann with Christine Reich and Anna Lindgren-Streicher
2009	NISE Network Regional Workshops: Second Round of Workshops	Amy Grack Nelson
2009	NISE Subawardee Year 5 Planning Meeting	Amy Grack Nelson and Denise Huynh
2009	Public Impacts Summative Evaluation: Study 2. Year 4 Progress Report	Christine Reich and Juli Goss
2009	Public Impacts Summative Evaluation: Study 3. Year 4 Progress Report	Christine Reich and Juli Goss
2009	RISE February 2009 Science Communication Seminar	Juli Goss and Elizabeth Kunz Kollmann
2009	RISE January 2009 Public Communication Internship Formative Evaluation	Elizabeth Kunz Kollmann
2009	Spiral Zoom on a Nasturtium Leaf	Adam Klinger
2010	Museum of Science Forum 5.1 Results	Juli Goss and Elizabeth Kunz Kollmann
2010	Nanosilver Program - Formative Evaluation	Al Onkka