Nano: Creating an Exhibition that is Inclusive of Multiple and Diverse Audiences

by *Rae Ostman* and *Catherine McCarthy*

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Nano is a 400-square-foot interactive exhibition designed by the Nanoscale Informal Science Education Network (NISE Net) that is hosted simultaneously at 93 sites across the country, including science centers, children's museums, libraries, and other informal learning organizations. This distribution model brings the exhibition to sizeable audiences: in 2015 alone, Nano will reach 11 million people. The exhibition's audience is multiple and diverse, due to the variety in the host sites' type, size, and geographic location.

In order to ensure that *Nano* was accessible to visitors with a range of physical and cognitive abilities and inclusive of visitors from diverse cultural backgrounds, the exhibition team embraced Universal Design principles during all phases of planning, development, evaluation, and fabrication. In this article, we describe the exhibition's goals related to accessibility, inclusion, learning, and engagement; explain the team's development process; provide examples of strategies, practices, and design decisions that may be relevant to other exhibition projects; and briefly summarize the results of extensive visitor evaluation and research as they relate to Universal Design.

Background

NISE Net is a national community of researchers and informal educators dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology ("nano"). The goals of the network are to create a national community of partners, to develop and distribute educational experiences that raise public awareness and understanding of nano, and to generate knowledge about public and professional learning through evaluation and research. The network was launched in 2005 with funding from the National Science Foundation. Some 600 organizations actively participate, including 350 museums that are located in all 50 states and Puerto Rico.

In the emerging field of nanoscale research, scientists and engineers study the novel properties and behaviors that occur at the scale of atoms and molecules and develop new materials and technologies in areas such as medicine, computing, and energy. A nanometer is just one-billionth of a meter, which is so tiny it's difficult to imagine. A strand of human hair is 80-100,000 nanometers wide, and our fingernails grow a nanometer every second. Because this area of study has such important potential implications for society yet is largely unfamiliar,[1] the exhibition team was committed to making the Nano exhibition accessible to and inclusive of the broadest possible audience.

The overarching goals for the exhibition are to provide an opportunity for visitors to learn about nano, to create an engaging experience that allows them to find personal relevance and meaning in the exhibition content, and to ensure that the exhibition is inclusive of and accessible to multiple and diverse audiences. The exhibition development team (including the authors) used Universal Design and inclusive audience principles together to ensure not only to physical and cognitive access, but also social and cultural inclusion, for museum visitors across the United States.

Fig. 1. Nano *at the Science Museum of Minnesota in Saint Paul. The photo shows the compact footprint of the exhibition and one possible arrangement of the modular components. Photo by Craig Thiesen for the NISE Network*

The *Nano* exhibition has a small footprint, but it engages visitors in learning about all four of NISE Net's key concepts for nanoscale science, engineering, and technology through interactive components and real phenomena.[2] As presented in the exhibition, these concepts are:

- Materials can act differently when they're nano-sized.
- Nanotechnology lets us build things the way nature does—atom by atom.
- Nano is all around us, in nature and in technology.
- Nanotechnology will affect our economy, environment, and personal lives.

The team made the most of this small exhibition by layering information and creating connections across interactive exhibits, graphics, and other elements, in order to allow broad access as well as deep exploration of content and ideas (fig. 1). *Nano* includes the following components:

- "Small, Smaller, Nano" exhibit, where visitors explore progressively smaller magnetic materials: magnetite sand iron powder, and ferrofluid.
- "Static vs. Gravity" exhibit, where visitors spin disks, comparing the relative effects of static electricity and gravity on different size beads.
- "Build a Giant Carbon Nanotube" exhibit, where visitors work together to build a giant model of a nanoscale structure.
- "I Spy Nano" exhibit, where visitors try a series of interactive challenges, then search a complex image for examples of real nano products and phenomena.
- "Balance our Nano Future" exhibit, where visitors balance blocks on a tippy table that represents the challenge of working together to build a stable nano future.
- A series of interactive graphic panels, including "What happens when things get smaller?" "What's new about nano?" "Where can you find nano?"
- A seating and reading area. Here, visitors can sit comfortably, read, and play with stuffed toys.

Planning and Development Process
The development team created *Nano* using a rigorous, collaborative process that included a variety of stakeholders. The *Nano* team's core members included exhibit and evaluation staff from the Science Museum of Minnesota in Saint

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Paul and the Sciencenter in Ithaca, New York. Evaluation, Universal Design, and bilingual design experts from the Museum of Science in Boston and the Oregon Museum of Science and Industry in Portland provided additional support.

At critical stages during the development process, the exhibition team solicited feedback on design criteria, content, and prototypes from a larger group of scientists and museum professionals. Experts in nanoscale science, engineering, technology, and its societal implications helped the exhibition team to define this complex, interdisciplinary field, identify interesting research and applications, and ensure the exhibition content was accurate. Museum professionals and experts in learning helped us to present those concepts in engaging and age-appropriate ways for a family audience. Universal Design experts, inclusive audience experts, and consultants with a variety of physical disabilities helped the team make the exhibition physically cognitively, socially, and culturally accessible and inclusive. The team also drew on expertise across the network in relevant professional practices.[3] Finally, exhibition team members directly observed and interviewed target audiences during an extensive process of iterative prototyping and formative evaluation.

Inclusive Practices and Strategies

The team used several strategies to make the exhibition a successful learning and social experience for multiple and diverse public audiences:

- Provide physical and sensory access to all aspects of the exhibition.
- Repeat and reinforce key concepts.
- Offer multiple entry points and multiple modes of engagement.
- Make connections to visitors' prior experiences and to relevant global issues.
- Create a welcoming environment that promotes social interaction.
- Use concepts, text, images, and examples that are sensitive to and inclusive of diverse cultures and backgrounds.

Below, we use the example of "Build a Giant Carbon Nanotube" and "Balance Our Nano Future" to explain some of the specific ways these points were addressed into the exhibition.

Physical and Cognitive Access

Nano accommodates individuals of different physical heights, abilities, and degrees of mobility, including toddlers, children, adults, and individuals using wheelchairs. Visitors can stand, sit, and move through the exhibition in different ways. Each element of the exhibition meets or exceeds ADA guidelines and utilizes principles of Universal Design.[4]

For example, at "Build a Giant Carbon Nanotube," visitors work together to construct a model of a nanoscale structure that can reach several feet in height, using building pieces that represent carbon atoms and bonds (fig. 2). It took several rounds of prototyping—including visitor observations and consultation with Universal Design experts—before the team identified dimensions and materials

Endnotes:

[1]Barbara Flagg, *Nanotechnology and the Public. Part I of Front-End Analysis in Support of Nanoscale Informal Science Education Network* (Bellport, NY: Multimedia Research, 2005), http://nisenet.org/catalog/evaluation/nanotechnology_public_year_1_front_end_evaluation.

[2]Marjorie Bequette et al., *Nanoscale Science Informal Learning Experiences: NISE Network Content Map* (St. Paul: Science Museum of Minnesota, 2012), http://www.nisenet.org/catalog/tools_guides/nanoscale_science_informal_learning_experiences_nise_network_content_map; Sciencenter, Engaging the Public in Nano: Key Concepts in Nanoscale Science, Engineering, and Technology (Ithaca, NY: Sciencenter, 2011), http://www.nisenet.org/catalog/tools_guides/engaging_public_nano_key_concepts.

[3]Museum of Science, *Universal Design Guidelines for NISE Network Exhibits* (Boston: Museum of Science, 2010), http://nisenet.org/catalog/tools_guides/universal_design_guidelines_exhibits; Kari Jensen et al., *Translation Process Guide* (Portland, OR: Oregon Museum of Science & Industry, 2011), http://nisenet.org/catalog/tools_guides/translation_process_guide; Rae Ostman et al., *Bilingual Design Guide* (Ithaca, NY: Sciencenter, 2012), http://nisenet.org/catalog/tools_guides/bilingual_design_guide.

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for the platform and building pieces that would accommodate visitors with the greatest possible range of abilities.

It was particularly challenging to design this hands-on, large-scale activity so that all visitors could reach and manipulate the model pieces at the start—when the structure is short—and later on as it grows taller. The final design has a relatively low building platform and a shallow storage bin that is accessible and safe for toddlers and young children, yet still allows adults and visitors in wheelchairs to reach the pieces. The freestanding design allows visitors access to all sides of the building area. A "prebuilt" portion of the nanotube in contrasting colors and materials provides an elevated area to build onto, for visitors with limited ability to reach or bend over. Large, light, durable foam pieces are easily manipulated, don't represent a choking hazard, and won't cause injury if thrown or stepped on.

It was also challenging to ensure that visitors of different abilities, backgrounds, and developmental stages had appropriate use instructions. For non-readers and blind visitors, the prebuilt portion of the nanotube demonstrates how to build the structure. The exhibit's label also includes line drawings that show sighted visitors how to add pieces on to the nanotube. The tactile AD symbol and braille label guide visitors to an audio description that provides verbal instructions for blind visitors.

Finally, the team created a variety of materials to provide cognitive access to the component's STEM (science, technology, engineering, and math) content, keeping in mind that many of our visitors included families with members of different ages. Key concepts from the building activity are repeated and contextualized on a graphic panel that asks, "What's new about nano?" The panel's large headline presents the main message of the activity, "Nanotechnology lets us build things the way nature does—atom by atom," while images provide additional scientific information and make connections to familiar materials made of carbon, such as diamonds and the graphite in pencils. The graphic also includes flip panels, which explore some of the ways that nature has inspired scientists to create new nanotechnology products, such as stain-resistant fabrics (inspired by lotus leaves) and tablet displays (inspired by butterfly wings). The audio description offers access to this information for blind visitors, while a large-print book provides an additional option for visitors with low vision.

Fig. 2. Family collaborating to "Build a Giant Carbon Nanotube" at the Sciencenter in Ithaca, New York. The older boy in the family is blind, and is working with his father and brother to build the model. Photo by Gary Hodges for the NISE Network

Endnotes continued:

[4]Science Museum of Minnesota, Nano *Mini-Exhibition Host Resources: Audiences* (St. Paul: Science Museum of Minnesota, 2011), http://nisenet.org/sites/default/files/catalog/uploads/8560/nano_mini-exhibition_audiences_12-23-11.pdf; Smithsonian Institution, *Smithsonian Guidelines for Accessible Exhibition Design* (Washington, DC: Smithsonian Institution, 1996), http://www.si.edu/Accessibility/SGAED.

[5]Gina Svarovsky et al., *Summative Study of the Nano Mini-Exhibition* (St. Paul, MN: Science Museum of Minnesota, 2013), http://nisenet.org/catalog/evaluation/public_impacts_mini-exhibition_study_year_8_summative_evaluation.

[6]Elizabeth Kunz Kollmann et al., *NISE Net Research on How Visitors Find and Discuss Relevance in the Nano Exhibition* (Boston, MA: Museum of Science, 2015).

Fig. 3. Family trying to "Balance Our Nano Future" at the Sciencenter in Ithaca, New York. The playing surface and blocks represent a generic but diverse community. Photo by Gary Hodges for the NISE Network

Fig. 4. The exhibition team consulted with Universal Design experts with disabilities. In this photo, a blind consultant is using "Small, Smaller, Nano" at the Science Museum of Minnesota in Saint Paul. Photo by Emily Maletz for the NISE Network

Social and Cultural Inclusion

The *Nano* team took particular care to ensure that the exhibition was socially and culturally inclusive. We designed all elements of the exhibition so that people with a range of abilities can participate to the greatest extent possible as a member of their visitor group, and we strived to be inclusive of visitors of diverse backgrounds, especially Spanish speakers, since Spanish is the second-most popular language in the United States (after English).

For example, at the hands-on game "Balance Our Nano Future," visitors use wooden blocks to build a town on an unstable table surface (fig. 3). We created custom illustrations for the playing surface and blocks that represent a generic but diverse community. The building area and blocks show urban, suburban, and rural living environments, while the people are depicted as young and old, with different physical appearances and abilities.

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Flagg, Barbara. *Nanotechnology and the Public. Part I of Front-End Analysis in Support of Nanoscale Informal Science Education Network*. Bellport, NY: Multimedia Research, 2005. http://nisenet.org/catalog/evaluation/nanotechnology_public_year_1_front_end_evaluation.

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Kollmann, Elizabeth Kunz, Gina Svarovsky, Stephanie Iacovelli, and Maggie Sandford. *NISE Net Research on How Visitors Find and Discuss Relevance in the* Nano *Exhibition*. Boston, MA: Museum of Science, 2015.

Museum of Science. *Universal Design Guidelines for NISE Network Exhibits*. Boston, MA: Museum of Science, 2010. http://nisenet.org/catalog/tools_guides/universal_design_guidelines_exhibits.

Ultimately, this effort created a more effective learning and social experience for all visitors to the exhibition.

Evaluation and Research

The *Nano* exhibition team benefited from and participated in the network's extensive research and evaluation program, which included front-end research, formative evaluation, summative evaluation, and research on learning. Evaluation of the exhibition was conducted at seven different museums, and included the general public, individuals with a variety of physical disabilities (blind, low vision, deaf, hard of hearing, and limited mobility), Universal Design experts who have disabilities and consult on accessibility, and monolingual Spanish speakers and bilingual Spanish-English speakers (fig. 4).

Evaluation and research studies on the exhibition conclude that *Nano* successfully transforms a topic that most visitors find not only unfamiliar but also unpromising into an experience that multiple and diverse visitors find highly engaging and relevant (fig. 5). The summative evaluation reports that *Nano* reaches multiple and diverse audiences and provides them with an enjoyable and social learning experience.[5] A research study on public learning in the exhibition determines that all visitor groups find relevance in its content.[6]

Conclusion

Universal Design principles and inclusive practices directly contributed to the success of *Nano*. The exhibition team, our collaborators, and our advisors weighed many factors and possible solutions and then made many interrelated design decisions and specific modifications in order to create an accessible and inclusive exhibition. Ultimately, this effort created a more effective learning and social experience for all visitors to the exhibition.

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Fig. 5. Family using "Small, Smaller, Nano" at Port Discovery Children's Museum in Baltimore, Maryland. Photo by Ken Stanek for the NISE Network

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