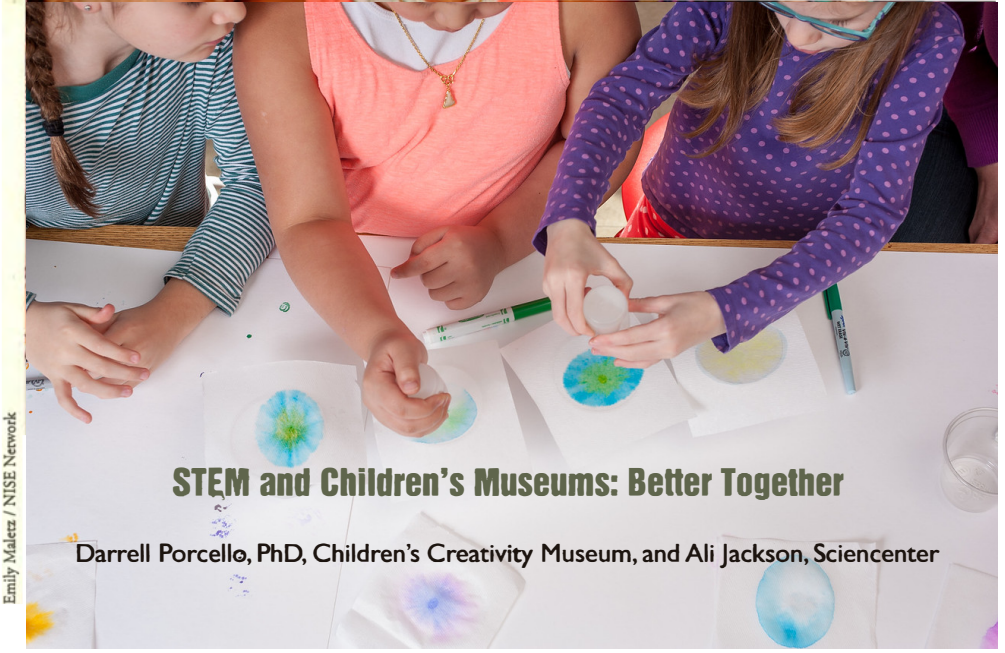


Emily Maletz / NISE Network

Young children create colorful artwork using real chemistry techniques in the "Let's Do Chemistry: Chemistry Is Colorful" activity.

STEM and Children's Museums: Better Together

Darrell Porcello, PhD, Children's Creativity Museum, and Ali Jackson, Sciencenter

Stakeholders both inside and outside the children's museum field have powered a rising tide of STEM (Science, Technology, Engineering, and Math). Families want young children exposed to this roaring engine of economic prosperity, and funders want early exposure and success to foster later STEM careers. Science and technology have become ubiquitous across children's media, with interest often driven through identifiable fictional characters and engaging narrative.

While children's museums are nimble and can quickly adapt to the pull of their audience, adding more STEM to the floor is also an opportunity to slow down and reflect. How can the unique world of children's museums—sparking wonder, blooming imagination, and fueling creativity in young learners—pull STEM into its orbit instead of the other way around? What STEM activities work especially well with young learners in our dynamic environments, and why? How can we empower families to do STEM together, recognize the curiosity of their young learners, and connect STEM activities with their everyday life and personal experience?

The National Informal STEM Education Network (NISE Net) creates educational products, including toolkits of hands-on STEM activities, covering a range of topics for a wide variety of partners including science centers, university outreach programs, and children's museums. For more than a decade, nearly 700 partners across all fifty states have successfully used these activities with diverse audiences. About a third of the partners in NISE Net are children's museums, and many more partners serve family groups with young—often very young—children. Through internal evaluation and feedback from active partners, NISE Net activity developers have made significant progress leveraging the strengths of children's museums and designing STEM activities specifically for these audiences. In this article, we step through examples from three complex, current topics: nanotechnology, Earth and space science, and chemistry, to highlight effective strategies for engaging young learners with STEM.

Nanotechnology

Nanotechnology, or the study of how the properties of matter change at the nanoscale, was the first content area covered by NISE Net—even though many advisors believed young children could not be a realistic target audience for resulting educational programming. NISE Net developers, including veterans from children's museums, decided to use the "surprise" and "wonder" of objects at the nanoscale to stimulate interest in young children. One popular strategy was to use game-like elements to help make the challenges in hands-on-activities feel more playful.

Gary Hodges for Sciencenter/NISE Net

During a NanoDays festival, "Horton Senses Something Small" story time is followed by hands-on activities such as guessing mystery scents in balloons. As tiny humans themselves, children love to learn about the wonder and power of tiny things.

In the NanoDays activity "Horton Senses Something Small," visitors learn that nanoscale particles cannot be seen, but can sometimes be detected by the sense of smell. Visitors listen to sections of the Dr. Seuss book *Horton Hears a Who,* about an elephant who can hear very quiet sounds that other animals can't. To further draw children into the story, visitors wear paper elephant ears throughout the program. After using a lens to look at small things, they investigate a series of balloons with scents inside, guessing which smells come from each balloon and matching them with pictures of the smell source. Facilitators help guide caregivers to encourage young children to think of their own noses as sensitive detectors that can recognize tiny scent molecules they cannot see. At the end of the program, each child receives a scented sticker to take home, helping to extend the learning experience.

Using a fun narrative is a great way to add context and stimulate visitors' imaginations. The *Horton Hears a Who* storybook introduces children to the idea that there is a world too small to see that can be investigated with our senses and tools—a fundamental concept of nanotechnology. The hands-on activities following the story allow young learners to develop and apply their investigative skills in an age-appropriate format. Another key part of this activity, which we will see repeated later, is its focus on real phenomena. Partner organizations reported that children were surprised and thrilled by the mystery scents from the colorful balloons. Focusing on something real

that children can investigate or manipulate is a simple but beautiful strategy to encourage STEM engagement with young learners.

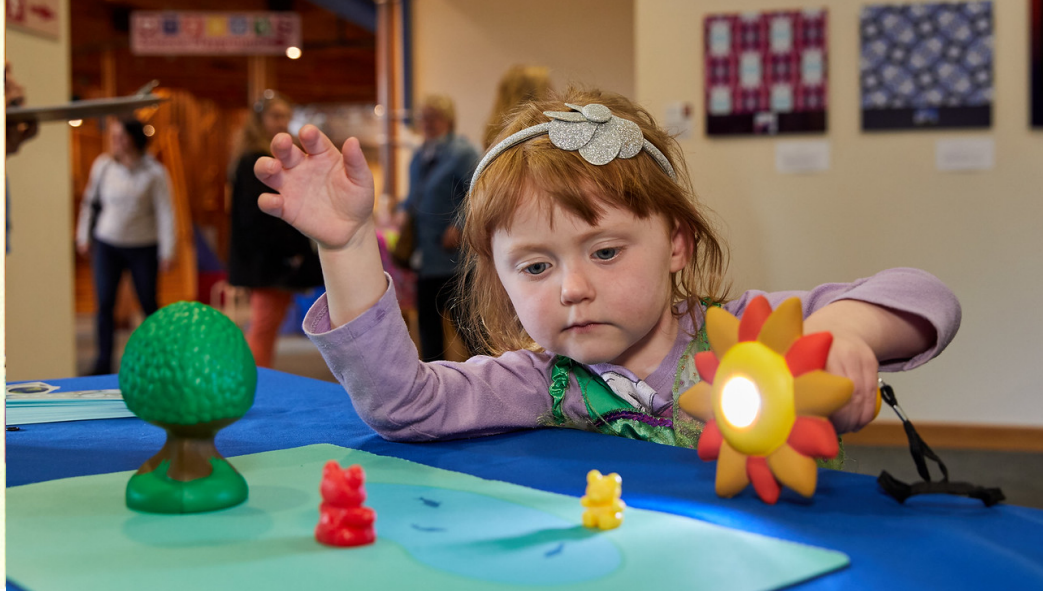
Earth and Space Science

NASA, galaxies, and alien worlds will always have many young devotees. While this content is popular and exciting, it is tempting to focus on overwhelming facts about the vastness of our world, the solar system, and outer space. In collaboration with NASA, NISE Net has created *Explore Science: Earth and Space* toolkits with hands-on activities that focus on real phenomena, the scientific process, and visitor participation for visitors of all ages. Working closely with the Astronomical Society of the Pacific, NISE Net also updated and expanded some existing "My Sky Tonight" activities specifically for young learners.

A young visitor manipulates the path of the "sun" in the "Explore Earth: Bear's Shadow" activity at an Earth & Space event. Shadows are a real-world, relatable phenomenon for children and a critical component of NASA science and mission planning.

In this activity, shown in the photo on this page, visitors explore shadows and the dynamic Earth-Sun system by using a flashlight and a toy bear. Young children love to take control of the flashlight and are soon gently guided by the facilitator to investigate how the bear's shadow changes when the "sun" moves. The inviting set-up and rich materials, with a squishy sun halo around the flashlight and a colorful set of toy props, encourages children to explore STEM concepts through play. Young learners engage in science process skills here, such as making predictions, observing, comparing and contrasting, and constructing explanations. Children have agency over a safe tool, creating many different types of shadows on their own. Working alone or with a facilitator, children can begin to model the way the sun casts shadows outside through simple questions: Where is Bear's shadow when shining the light straight down on him? How can Bear's shadow be longer or shorter? Where is the light when Bear's shadow is in front or behind him? Skilled facilitators can also use an experience like this to encourage children to make claims about what might happen before experiments are carried out.

Similar to the nanotechnology example, this toolkit uses a book, *Moonbear's Shadow* by Frank Asch, to set context and give life to the captivating characters who assist children in the discovery process. The STEM here is real and results organically from play. NISE Net partners have reported this toolkit activity to be one of the most successful in reaching young learners.



Dave Burbank, Sciencenter / NISE Network

Creativity Meets Science at the Children's Creativity Museum

Images from space can be breathtaking. NASA's Universe of Learning (NUoL), an integrated astrophysics STEM learning and literacy program, and the Children's Creativity Museum, a core member of the NISE Net development team, recently prototyped a new space science, festival-styled event called Space Art Exploration centered around visual arts.

Thriving in the heart of a technology-driven city, the museum uses diverse programing that inspires self-expression, emotional growth, and creativity to deftly integrate STEM content from local stakeholders. Museum educators used this strategy to tell the story of nebulae—clouds of gas and dust pushed out from dying stars—that were significant factors in the formation of the solar system. NUoL content experts and museum educators noted visual similarities between the fundamental forces of nebulae and children's manipulations of paint and wax. Nebulae mixing elements in space is essential for creating new stars, planets, and life as we know it. Children can mimic that process by swirling paint in shaving cream. To get an idea of the tremendous energy of a dying star pushing out material, children use a salad spinner to spread out paint. The twisting transformations of resulting nebulae due to neighboring gas and debris can be approximated by the random shaping of hot wax in ice cold water.

Modeled from a tested NISE Net activity template, museum educators added key science messages (e.g. "A nebula is nature's way of mixing up materials in the space."), question prompts (e.g. "What colors from your nebulae art can you see in the nebulae images from space?"), and compelling science images (the Hubble Space Telescope's image of the Cat's Eye Nebula) that families discover in the course of the hands-on experience. Most children at the event stopped at all three activity stations described above, repeating each experience with different colors and ingredients. All visitors left with beautiful take-home creations, feeling a little more connected to far-off space phenomena.

Chemistry

Due to concerns about safety or unfamiliar science, chemistry is a STEM topic that is often last on the list for many informal educators. NISE Net, working closely with the American Chemical Society, wanted to address this apprehension directly. With a suite of creative hands-on STEM activities and new facilitation techniques, NISE Net developers aimed to help visitors of all ages develop positive attitudes toward learning about chemistry.

The activities in the *Explore Science: Let's Do Chemistry* toolkit define chemistry in terms of who uses it and why. This emphasis on people doing concrete things rather than

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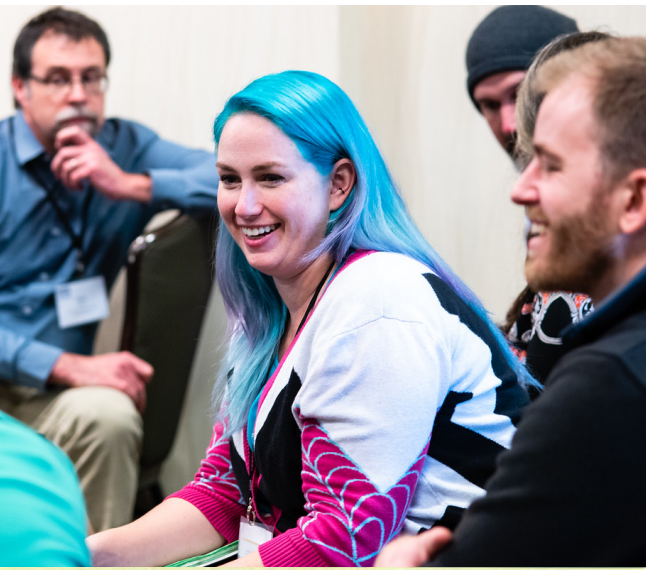

NISE Network partners converse and participate in a session focused on early childhood learning and resources at the 2019 Explore Science: Earth & Space Partner Meeting in Tempe, Arizona.

NISE Net and its partners are committed to developing better materials and facilitation approaches for younger learners and their caregivers. The network holds periodic regional or national meetings to allow professionals to meet, share ideas, and learn from each other. These in-person experiences and regular online connections bring attention to ideas that eventually bubble up into toolkits and other NISE Net resources—allowing partners to learn from each other and help to advance the children's museum and science center community.

We welcome and encourage educators working with young children in museums to join in the conversation and join the NISE Network. Learn more at www.nisenet.org.

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on abstract scientific concepts helps connect the chemistry that visitors explore during the hands-on activities with the many chemistry processes that shape our world. A good example is the toolkit's "Nature of Dye" activity, in which visitors use cochineal bug parts to make a deep-reddish dye, similar to what indigenous people in Central and South America use to color fabrics. Visitors are encouraged to further experiment with the dye's color, and quickly discover how changes in pH can result in distinct shades of red, orange, and purple. These vibrant changes foster excitement for learning that can be shared between visitors and educators, regardless of their experience with science.

The "Chemistry Is Colorful" activity helps visitors explore how the process of paper chromatography helps separate mixtures and identify materials. First, visitors make a colorful pattern on filter paper, using water drops to carry pigment from water-based color markers across the paper. Next, they do the same with three black markers, and match the resulting patterns to mystery chromatograms. Children are invited to look closely at the patterns, and observe how the colors separate and mix—hopefully increasing their interest in the nature and manipulation of color. With a little yarn and a few more experiments, their chromatograms become lovely take-home bookmarks to share with friends and family, creating personal relevance. Mixing art and science by using real tools to make new creations powerfully contributes to self-efficacy, or belief in one's own abilities, in children around STEM topics.

Conclusion

Children's museum partners and practices are core to NISE Net's work. Our development process and products are inspired by children's museums' dedication to encourage the joy of playful and experiential learning. The STEM learning strategies highlighted above nourish children's creative minds, opening up new possibilities to spark interest in the world around them. Specifically designing hands-on STEM activities for young children, and considering different strategies that work well for the children's museum audience, improves the experience for learners of all ages.

Everyone benefits from more creativity, more imagination, more wonder, and more play!

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