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Noyce Leadership Institute: Explorations in Adaptive Leadership

By Eugene R. Schnell, PhD

The leaders profiling their stories in this issue worked together in Cohort 4 as part of the Noyce Leadership Institute (NLI). NLI was created by the family of Robert N. Noyce, co-inventor of the integrated circuit, and generously supported by the Noyce Foundation as well as by the Moore Foundation, Packard Foundation, and the US Institute for Museum and Library Services (IMLS). NLI was started in 2008 to help prepare the next generation of leaders for science intensive museums, with a particular emphasis on gaining the skills and perspectives needed to increase the engagement of those organizations with their immediate communities. Five cohorts of participants (now totaling 88 people from around the globe) have completed the 14 month NLI experience.

Each participating organization sponsors an "NLI fellow" and a strategic initiative (SI). The SI is meant to serve as a seed for increased focus on external constituencies and for building programs that are closely linked with the daily lives and everyday challenges of visitors and citizens. Fellows are encouraged to select large boundary-spanning projects that are collaborative, risky and have unclear outcomes. In essence, the SI becomes a type of "leadership laboratory" where NLI Fellows create a micro-environment for applying new models and behaviors, building peer support and reflecting on their capacities for leadership. The design for NLI is rooted in the ideas of action learning (Conger & Benjamin, 1999).

NLI aims to create a cadre of executives for informal science organizations that can successfully guide the next era of organizational and community changes that lie ahead. Those leaders will have to encounter a range of "adaptive challenges" that will re-shape assumptions, re-direct patterns and re-deploy resources. Each Fellows' SI is an experiment meant to test the dimensions of those challenges and to offer a platform for practicing adaptive leadership (Heifetz, 1998). As such, leadership is learned as a skill that is highly dependent on context, not a personality trait nor a routinized set of steps. Each of the Cohort 4 stories that follow is as much written by the Fellows as it was written upon them during their intensive leadership learning experience.

More information about the Noyce Leadership Institute can be found at http://noycefdn.org/NLI.php.

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Leadership for Innovation at the Museum of Science

By Andrea A. Durham

Summary: Innovation comes in many forms. In this article I highlight some of the leadership qualities employed at the Museum of Science, Boston, during the development of a new project that was a stretch for the organization, requiring new ways of doing things and new ways of thinking about how exhibits can be created and sustained over the long term.

Background

The Museum of Science, Boston has a long history of innovation. It was founded in the 1830s as the Boston Society of Natural History, an organization dedicated to the study and promotion of natural history, establishing a museum, publishing a scholarly journal, and hosting meetings and lectures. The "modern era" of the Museum dates back to the 1950s when Bradford Washburn realized his vision of creating a science museum that would appeal to everyone,

situated on the Charles River Dam between Boston and Cambridge. His vision was to include all the sciences under one roof, and to engage visitors of all ages and interests through the variety of the content, including live animals and "interactive" exhibits. His leadership inspired an entire generation of Museum staff to realize this vision over several decades, including several expansions, and significantly advancing the field of informal science education. A press clipping from the era depicts the mayor's excitement at being the first to use an interactive, which consisted of pushing a button to see a scientific phenomenon in action!

In the 1980s the Museum embarked on the "Science is an Activity" long-range exhibit plan, creating a series of exhibitions that engage the visitors in science thinking skills. Each highly interactive, hands-on exhibition gave visitors a chance to practice, understand, and engage in a particular thinking skill: The Observatory (now called *Take a Closer Look*) focuses on observation, *Investigate!* gives visitors opportunities to practice experimenting, *Natural Mysteries* engages visitors in collecting and classifying, and in *Making Models* visitors get to make their own models as part of the scientific process. These were some of the most highly interactive, constructivist-based exhibitions known to the museum community at the time of their creation. They also were the laboratory for innovations in universal design with such features as extensive use of audio labels, touchable collections objects, and hands-on components that were usable by people with a wide range of abilities and disabilities. These advances have been widely shared with the field of informal science education. And these exhibits have proven to be visitor favorites, standing the test of time.

Leadership Needs to Fit the Organizational Goals
The success of this series of exhibitions relied on strong vision and leadership, as well as the necessary organizational skill sets. At the time this long-range exhibit plan was created, the exhibits department at the Museum of Science was well positioned to accomplish the ambitious goals that were encompassed in these thinking skill exhibits. Multi-disciplinary staff were in place, team processes were in use, and the leadership instilled a high degree of commitment to the vision that the plan represented. Interestingly, the exhibit plan relied on the widespread application of science thinking skills to our own process! We employed vast amounts of observation, experimentation, collecting and model making – all as part of idea development, grant writing, prototyping, and throughout the exhibit development process.

Changes at the Museum of Science
While the "Science is an Activity" exhibit plan was in the final stages of completion, a number of organizational changes were taking place at the Museum of Science. We merged with the Computer Museum, moving their initiatives and some of their exhibits and collections under our roof; a new President and Director came on board (Ioannis Miaoulis); and technological literacy became a significant aspect of our mission. The Museum had been increasing its focus on the technology part of STEM education for several years, but now engineering and technology were increasing in prominence and importance for us.

How Does This Change Our Organizational Needs?
Science thinking skills have a particularly timeless quality. Part of what makes science thinking skills so valuable, and essential for our youth and general population, is that they can, and indeed should, be an integral part of one's life and in the activities contained in the exhibitions we had created. The exhibits have a long lifespan in part because the activities involved visitors in those core thinking skills. They have been updated, of course, which has been driven by several factors: 1) they wear out with 1.5 million visitors a year enjoying them! 2) our research and evaluation department's work yields a robust body of knowledge—about how our visitors enjoy the exhibits, what they gain from interacting with them, and how to most effectively engage our visitors--which leads to improvements in the exhibits over time; 3) our exhibit maintenance and technical design staff continually gain experience with how to build and maintain the interactives, so that they can be rebuilt with increased robustness or new features.

What is Technology?
As part of our increased focus on technology, we embarked upon the creation of a new exhibit, with the working title What is Technology? As we began the development process, we reflected on the very broad and often misunderstood topic of technology. Our thinking began with asking ourselves, "What should exhibits focused on technology and engineering include?", "What thinking skills are associated with technology?", and "What IS technological literacy, anyway?"

We studied surveys of public perceptions of technology, which consistently illustrated that the overwhelming majority of the public, when asked what they thought technology was, gave examples of their current electronic devices. In addition, in the public vernacular the word "technology" is usually synonymous with the latest electronic devices, such as the iPhone, or a computer. Indeed, in many school systems, technology class is the term used to describe a class that teaches various computer skills.

Many organizations have published definitions of technology, and they are in close agreement, describing technology as the process by which humans modify the natural world

to meet their needs and wants (ITEA 2000/2002/2007, NRC 2002). Our team conversations always drew us to the same conclusions: while there is a strong process element to understanding technology and engineering (usually termed the engineering design process), technological literacy requires an understanding that technology includes everything that humans have ever modified to meet their needs and wants. Technology goes back to the earliest humans and their modification of the natural world to create tools, and spans all of history right up to the latest microchip-based devices. Of course no exhibit can be all-inclusive but we felt that a mix of thought-provoking historical and cutting edge artifacts, as well as stories and examples of the processes used by inventors of technologies, old and new, will be needed to enhance visitors' technological literacy.

In order to reach a wide range of audiences, including multi-generational visitor groups, we wanted to strive for artifacts and stories that would inspire visitors to share their personal stories and memories with each other. In addition, one of our main goals was to have a dynamic, frequently changing exhibition that aligned with the current and cutting edge aspect of technology in order to maintain interest and excitement about the exhibit among our frequent visitors. But of course we had space constraints, limiting the number of artifacts and stories we could present.

> "My focus would be on leading organizational change that would enable the team to think differently."

Over time, we concluded that for this project to be successful, it needed to achieve dual outcomes: to create the exhibition and to develop a process for keeping it current. We needed to design an exhibition that would be flexible enough to change over time with a reasonable amount of money and effort, and we needed to develop a sustainable organizational process for making changes with some frequency.

The Museum of Science and other museums have experimented with models for accomplishing this in various ways in the past, but we felt that a new process would be required to ensure success.

Enter Noyce Leadership Institute (NLI)

Noyce fellows spend their 14 months in the program working on a strategic initiative (SI) that develops our leadership skills by actively working on a project that challenges us to stretch and grow. This project was a perfect fit, given that organizational change would be needed to achieve our goals. My focus would be on leading organization change that would enable the team to think differently about two principle areas: partnering more deeply with the community, and creating a sustainable model for frequently changing exhibit components.

Leadership for Innovation

We all know from personal experience that organizational change is difficult. We also know intuitively that "business as usual" doesn't typically result in innovation unless your usual business is constantly cranking out innovation (we all know people and companies who provide examples of this). I also want to acknowledge that the word innovation can be a subject of controversy, so let's agree that in the context of this example, it is being used to describe one organization's need to dramatically change our ways of thinking and doing in order to accomplish something very new and different for us. And this required leadership that would enable the team to be successful in these new challenges.

Why did we need to think and act differently? The way we had developed exhibits in the past was a well-tested, multi-stage development process which worked well in many ways, producing lots of terrific exhibits. Participants in the process were Museum staff, advisors, and visitors. In order for the *What is Technology?* exhibits to be developed rapidly and cost-effectively, and so that they can be changed on a regular basis in a sustainable and timely manner, we needed to work with partners, and we needed to involve them in a deep level of engagement. This was new for us, and involved entirely different ways of thinking and doing. Some of the fears were: loss of control, the long learning curve in working with partners (both for us, learning their organization, processes and skill sets; and for them, learning about us and the ways of informal science education), and the possibility that it might slow down the process rather than speed it up.

Leadership Lessons Learned

Many adaptive challenges were embedded in this organizational change process. Exhibit development is an intensively team-based, collaborative, and creative process, which evolves over the long-term. And it is not readily summarized in a short article. But some of the very practical, on-the-ground lessons learned throughout this process are:

1. *Treat the organizational change process like an exhibit development process.* There are many similarities. Both are highly collaborative processes, which benefit from many points of view; both experience multiple phases as they march toward the end result; both require extreme creativity while remaining grounded in core principles and goals; both take time, patience, inspiration, perspiration, and are in the end a very human endeavor.

2. *Be patient.* As a leader, you have a vision of how it should all end up. But we also know that a team of people need to create their own vision in order to have a personal investment in the outcome and do their best work. Yes, this is stating the obvious, and yet it can be so easy to forget, to lose patience and want to fast-forward to the endpoint that "I knew we needed to get to all along." Always keep in mind that giving the team space to create their own version of the big vision WILL result in a better outcome than one person, regardless of how brilliant he or she is, will create. And the team will be invested in its success, which is, of course, priceless.

3. *Know when to push.* Give the team space, but stay involved enough to know when to push. It's a fine line between letting the team's vision evolve in due time and sticking to a reasonable timeline. Create milestones, agree on them early in the project, and stick to them.

4. *Recruit one of the team members to document the knowledge gained over the course of the partnering relationships, and continually add to your body of knowledge.* Particularly when it comes to working with partners, there's a significant learning curve. The better you can document that and make it transferrable to new partnerships, the faster you'll get new partners up to speed. Include clearly defined roles and responsibilities; be able to clearly articulate your internal process and expertise; and don't assume the partner knows anything about museums or developing exhibits!

5. *Include a project manager who's a great fit in your leadership team.* It's essential to have a day-to-day leader who is an integral part of the team and understands the importance of adaptive change. Much more could be written about this role, but the essential qualities are: the ability to be committed to your high-level long-term goals while being a great member of the project team, the ability to be the primary balancer and navigator of that fine line between giving the team enough creative room and sticking to the milestones, and, of course all the other classic project management requirements. Yes, it's a demanding role!

"It is essential to have a day-to-day leader who is an integral part of the team and understands the importance of adaptive change"

Outcomes

Adaptive change is continual and the *What is Technology?* project is no exception. We began with one pilot project that took place during my Noyce fellowship, which was declared a success by all participants in the end. That said, it took longer than we expected, and had bumps along the way, but no one lost their deep commitment to the project, and both the Museum and the partner felt that it was a valuable learning experience. Some of the lessons learned in the previous section came out of this pilot project. We want to leverage that knowledge by doing another exhibit together, and that desire illustrates the satisfaction that both partners experienced.

The Museum is also actively applying the lessons learned to new partnerships. As this article goes to press, three more partnerships and their associated exhibit components are nearing completion, representing a wide variety of technologies and approaches. They have proceeded significantly faster, and the process has been adjusted and customized to be appropriate to each project's requirements, which has proven to be an essential part of the process. This is not a cookie-cutter formula, but a continual learning endeavor.

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The Making of Q?rius: A huge Community Effort

By Shari Werb

Going Behind-the-Scenes at the National Museum of Natural History

Until I began working at the National Museum of Natural History, I had not realized the depth of its scientific expertise and research facilities. Like millions of other people each year, my family visited the Museum and appreciated the science presented in the exhibitions. But, little did I know, (and, according to our visitor studies, little did 67% of visitors know), that just beyond the exhibition walls there are hundreds of experts working. These are the collections professionals, scientific illustrators, conservators, and scientists conducting original research, doing fieldwork around the world, and studying historic collections using cutting-edge technologies, and then casually discussing their work each day in the Museum's staff café. These people are a powerful and unique resource that can help make science relevant on a personal level to the public.

Learning to Create a Learning Center

Prior to my arrival in 2008 there were already discussions underway about creating a new learning center as part of a major renovation project near the Museum's Constitution Avenue entrance. Many of the science staff had fond recollections of the Naturalist Center, a pioneering learning center developed in the 1970s that engaged the public with its accessible collections and was also regularly visited by the Museum's scientists. In 1995 the Naturalist Center closed during construction for the IMAX Theater and Atrium Café and was later relocated to a facility in Leesburg, Va., where visitors could explore the 36,000-object learning collection and participate in educational programs and workshops. The Center remained there until 2011 when these collections were returned to the Natural History Museum.

We learned a great deal about object- and inquiry-based experiences during the 30 years the Naturalist Center was in operation and from managing different types of learning spaces for large and multi-generational audiences in the Insect Zoo and the Discovery Room. Over the past four years we ran the Forensic Anthropology Lab, as part of the Museum's *Written in Bone* exhibition, and this project contributed to our understanding of what it means to partner with scientists on the development of a learning experience. The research from each of these learning spaces, together with benchmarking trips to San Francisco (Exploratorium, California Academy of Sciences), Los Angeles (the Skirball's Noah's Ark, the Los Angeles Natural History Museum, California Science Center), Chicago (the Field Museum and Museum of Science and Technology) and New York City (American Museum of Natural History), would help inform the development of the new learning center.

The National Museum of Natural History hosts over 8 million annual visitors, and with the allocation of 10,000 square feet of prime real estate on the ground floor, we had the opportunity to help address some of the challenges our society faces around improving scientific understanding in America. We envisioned creating a world-class center in the heart of the nation's capital to inspire learning, spark curiosity, and ignite the minds of the next generation of scientists and citizens through personal interactions with our science experts. We also imagined creating activities and experiences that were inspired by our scientists' research (including climate change research, biodiversity of coral reefs, feather and bone forensics, and the Anthropocene), making available the high-tech tools that scientists are using (petrographic microscopes, opto-digital microscopes, and cell imaging stations) and connecting distance learners and visitors to field research sites (NOAA Ocean Research Vessels, Olorgasaille, Kenya, Hell Creek, Mont.), to the Museum's collections, and to labs and research facilities. Through interactions and experiences with passionate people who "do science," visitors would come away with a better understanding of how relevant science is to their lives – and how relevant they are to science.

The core project team involved with space planning included architects, engineers, scientists, educators, an exhibit designer, and a technology expert. Over time, the large space—once occupied by the Natural History Library and staff offices—was reconfigured into a silver LEED certified, two-level, highly flexible and transformable facility with six distinctive learning environments: On the ground level is the field, a large (4,000 sq. ft.), dynamic, flexible open space that accommodates a wide variety of learning experiences; the collections zone with a built-in, two-story wall display and cabinets that hold 6,000 publicly accessible, curated, conserved, and digitized objects with an adjacent work area; a glass-enclosed lab (900 sq. ft.) with built-in storage and wall display, sink, and center-pivot swing glass doors that, when opened, allow for natural flow into the field; and the theater, a 100-seat, multi-purpose space with retractable seats and a flexible layout which has distance-learning equipment and technology allowing for direct connections to labs and field experiences. The loft and the studio are spaces on the mezzanine. The loft is

1. Q?rius in Action; 2. Q?rius Collection Zone (side view); 3. Q?rius in Action; 4. Q?rius Collection Zone (view from the Loft above); 5. Q?rius collections in use. (Photos 1 and 3 by James Di Loreto, Smithsonian; Photo 2 and 4 by Ron Blunt Photography; Photo 5 by Brittany M. Hance, Smithsonian)

flanked by the floor-to-ceiling collection wall and is designed to be an informal gathering space that encourages small group conversations. The studio is another space for distance learning, video conferencing, and classes that can seat up to 30 people.

We hired Slover Linett Strategies to conduct a front-end visitor evaluation to help us identify the elements of an ideal museum experience; learn how visitors and non-visitors perceive NMNH's scientists, collections, and research work and feel about interacting with them; shed light on what else would make science relevant and inspire learning; and identify models of successful innovation in informal learning, both within and beyond the science and museum sectors. They interviewed visitors (and non-visitors) about what made museum experiences particularly interesting, memorable, engaging, or inspiring and ultimately identified six key elements to focus on: relevance, customization, immersion, dynamic content, one-of-a-kind experiences, and a sense of wonder. While many visitors interviewed said they often enjoyed one or two of these elements during a visit, we were looking to create an experience with all six.

Our cross-disciplinary innovation team brought diverse backgrounds to this project including exhibit development and design, object- and inquiry-based learning methods, scientific expertise, audience engagement and learning research, and interaction design and strategy. We also used Slover Linett's 10 strategic recommendations to help guide the development: 1) collections objects need to be integrated into an activity or process to be compelling; 2) interactions with NMNH's people in the Center need to be personal, entertaining, and readily available; 3) the space itself should be memorable, with a distinctive personality; 4) it should accommodate a wide range of preferences –

especially with respect to passive and active participation; 5) the center should provide assistance and tools to help visitors "assemble" their own learning center experience; 6) the learning center experience should be integrated with the rest of the museum; 7) we should help visitors "take the learning center home" with them; 8) we should consider making adults a key target audience; 9) personality matters; we should think strategically about the tone of the tone, especially with respect to humor; 10) we should build in ongoing evaluation, formally and informally.

The space was designed to accommodate a wide variety of activities and experiences. We brought together components that can be reconfigured in many different ways and for multiple purposes. We have acquired in-kind donations of cutting-edge microscopes that are exciting to use for both our scientists and the public. We have installed technologies that have more potential than we will initially realize. Our diverse collections are available for exploration and provide evidence and stimuli for convening conversations around important environmental and cultural issues our society faces in today's world. The place will serve as a learning laboratory both for our visitors and for us. We are committed to observation, evaluation, and learning research and are excited about what will happen in the space that we haven't even imagined.

Room with a "Q"

We attempted to find a good name for the space on our own, but eventually brought in an expert to help us. We wanted to communicate that it would be a place to BE and to DO, that the experience was more a verb than a noun. We wanted the name to be engaging and exciting, with a sense of fun, but not too kid-like. We thought it should be forward-thinking, 21st century, cutting-edge but still inviting, and that it should reflect the multimedia, multi-tasking, remix/mashup culture that today's teens live in, involving the web, texting, Twitter, YouTube, and more. Twenty-five names were selected, 10 were tested by visitors and of these, we chose "Q?rius" (pronounced curious) for its power to inspire the next generation of questing and questioning citizens and STEM professionals with curiosity and excitement for the natural world.

It Takes a Community

The National Museum of Natural History serves a national and international audience, and while 11% of its audience comes from the Washington, D.C., area, there are many young people from under-served communities living close by who do not visit the Museum. In 2010, I participated in the Noyce Leadership Program, which is committed to increasing the impact of science organizations in their community. As part of this program I led a strategic initiative that involved connecting young people from the Washington, D.C., community with Smithsonian science, especially teens from underrepresented communities. With 10-18-year-old youth as the primary audience for Q?rius, we began to create teen advisory groups. One working group spent six months helping us to design our loft space. Our summer middle-school group prototyped our activities and provided important feedback. When we found we had challenges with activity development, we invited our teens to help us figure out the solutions. Our youth volunteers, the "Q Crew," will become our ambassadors and activity leaders on weekends. These teens are now excited about Q?rius and will be participating actively with our opening events. They have begun to engage their peers in science and the museum through social media.

It was essential to engage the entire Museum community in the making of Q?rius. More than 180 volunteers, interns, and staff members, including exhibition developers, building engineers, scientists, collections experts, technicians, IT professionals, and educators, helped make it a reality. An additional 150 volunteers will be working in Q?rius once it opens.

Because of the unique nature of this project, the process for developing it proved to be different from creating other exhibitions, from managing the behind-the-scenes research and collections to the way metadata is typically presented in scientific databases. As a result, each person who contributed was regularly challenged to create innovative solutions and approach their work differently. For example, the Collections Zone experience was created in partnership with more than 100 scientists and collections professionals. Over 6,000 objects were chosen from the Naturalist Center's teaching collection for use in Q?rius. These objects needed to be housed in sturdier boxes for more frequent handling, and the objects selected needed to be selected cautiously because of the broad public use. Collaboratively with the Museum's IT department, database experts, and informatics specialists, we decided to use the Museum's EMU collections database, but utilized additional tools to create a user-friendly collections browser that provides onsite, online, and mobile access to the object and specimen information, scientist biographies, content narratives, links to relevant resources, activities, multimedia, and images of each object in Q?rius.

Each staff member who contributed to the project has become a stakeholder whom we will continue to invite to engage with our public. Q?rius will be successful only if it stays relevant and meaningful to both our teen audience and our internal community and if it continues to inspire and challenge both.

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Science Center NEMO in Amsterdam: from Good to Great, from Nice to Necessary

By Amito Haarhuis

The Noyce Leadership Institute has influenced me and my organization to focus even stronger on the larger role of our science center in society. The NLI has the motto that it wants science centers to go 'from nice to necessary'. We as an institute have adopted this motto, and have incorporated it in our strategic plan for the next five years. We want to go from an institution that is nice to have in our community to an institute that is necessary, because it is rooted in the city of Amsterdam and the Netherlands. We are an integral part of the Dutch society, and can make a big difference with regard to needs of that society. We learned to 'listen louder' to what the society needs. In this way, we can hopefully gain public trust and create support for our organization and our mission.

Introduction
In 2013, Science Center NEMO in Amsterdam celebrated its 90th anniversary. We have adapted to changing times and a changing world. With its more than 500,000 visitors annually, NEMO is the number five museum in the Netherlands. This is a good score, but we set our aims higher. A modern knowledge-based society, such as our current one, cannot do without a National Science Center. NEMO offers the basic principles of science and technology to a general public. This way, the public can better understand the world around them and they can play their own part in the search for solutions for the 21st century.

Our foundation is solid: a strong financial basis; large number of visitors; a solid national brand; an iconic building; successful exhibition concepts; an educationally-sound vision; motivated staff and excellent networks and collaboration with science, the business sector, education, other museums and the media. This is the right moment to consolidate NEMO's success and to adapt once again to the challenges of the 21st century: we want to go from good to great and from nice to necessary. Therefore, we are in the process of making a new strategic plan for the next five years. As part of this process we are revisiting our mission, vision and key values, and we are formulating new strategic goals. This process is ongoing and not yet finalized. So everything you read in this article might still be adapted. With regard to our new vision and mission, we would like them to be short and simple:

Our Vision
Science and technology are a major driving force in our world and they enrich our lives. Thanks to science and technology we increasingly understand ourselves and the world we live in more fully; they help improve our quality of life and support human development.

Our Mission
It is NEMO's intention to make people of all age groups experience how fascinating, exciting and useful science and technology are.

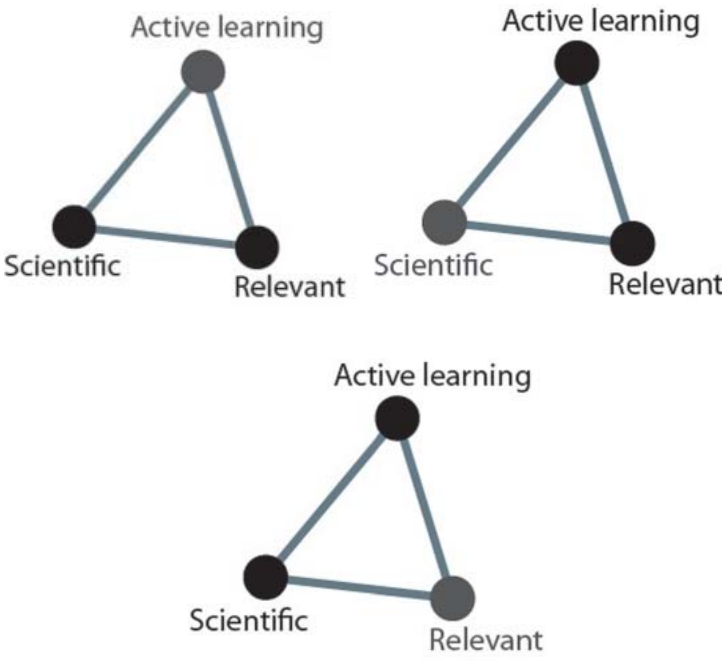
The NEMO Values
NEMO actively shows the general public how fascinating, exciting and useful science and technology are. We do so

by providing a large variety of programs, activities and events. But what is the common thread in all this? Running through all these activities is the aim to involve our public actively. All our programs are fully up to date with the latest scientific insights. We make people think about scientific and technological developments. This is defined in three key values: 1. Active Learning, 2. Scientific and 3. Relevant.

1. Active learning
Since we are a typical science center, the public can interact in our exhibitions to a very large degree and many activities are hands-on. Besides, NEMO continuously creates further options for social interaction within this learning process. The specific design of the exhibitions stimulates the interaction between parent and child (family learning). This way, parents play a more active role and children absorb more in-depth knowledge. Our visitors can actively participate in our museum. They are given the opportunity to leave comments or they may interact in the design of the exhibition by carrying out a specific activity. As such, we respond to the fact that visitors wish to contribute actively to their environment, partly because of the influence of the social media.

2. Representative of the sciences
The general public looks upon NEMO as being the representative of the sciences. Therefore we carry a large responsibility, which is the reason that all our programs are always up to date with the latest scientific insights and that we always test their scientific accuracy. Scientists are actively involved in the development of our programs. We also organize one-to-one contact between them and the public. Indeed, nobody can represent science better than the scientists themselves. Having scientists carry out research together with the public, the museum makes research transparent and concrete. Our exhibitions and programs present the scientific facts and we leave it to our audience to give a value judgment. Thus, NEMO remains an independent and trustworthy organization. The largest, and most often visited, popular scientific website in the Dutch language is made at NEMO: Kennislink.nl. Our programs and exhibitions increasingly tie in with Kennislink.nl, resulting in more in-depth scientific knowledge.

3. Incentive for society
It has become a 90-year old tradition in the meantime: NEMO and its predecessors focus on the world around them. Society's requirements determine our strategy. Anyone who learns about science and technology expands his world and creates opportunities. For this purpose, NEMO actively encourages the increase of scientific literacy in our society. NEMO has developed great expertise with respect to educational programs. Throughout the Netherlands, we make boys and girls enthusiastic about science and technology and we encourage them to develop their talents to their full extent. As such, we respond to the demand of our knowledge-based economy to make a new generation ready for these essential professions. Being a trustworthy and independent organization, NEMO brings various interested parties together to discuss the implications of scientific and technological innovations.



Three different key values present throughout NEMO museum programming

A Solid Foundation
Our future is based on a solid foundation as is evident from the results. NEMO is operating successfully. The public appreciates what we offer. For the last three years, more than half a million visitors have annually visited the museum. The financial basis is therefore perfectly sound. In 2012, more than fifty per cent of our revenues were derived from our own exploitation. On top of this, we also receive the growing support and recognition of the public authorities, the business sector, funding organizations, knowledge-based organizations and other collaborating partners.

Facts and Figures:
• More than half a million visitors in the last three consecutive years. In 2012, NEMO was the number five museum in the Netherlands with 527,000 visitors [1]
• In 2012, 17% of the 527,000 visitors (91,000) were educational visitors
• In 2012, the NEMO website counted 612,000 unique visitors
• Visitors to the Science Center give our total program an average score of 8.6 (on a scale from 0 to 10)
• The average time spent in NEMO amounts to 4 hours and

16 minutes, significantly longer than is the case with other museums for technology (3 hours and 28 minutes) and museums in general (2 hours and 47 minutes) [2]
• The strength of the NEMO brand grew between 2010 and 2012: from a strong regional brand to a national brand[3]
• The NEMO Science Learning Center carries out a great many national educational projects. In total, the Science Learning Center reached 251,000 pupils in 2012, 160,000 among them from outside NEMO
• Kennislink.nl counted 2.8 million unique visitors in 2012
• We are a financially sound organization with 58% revenues from our own exploitation in 2012, 14% museum-generated revenues from partners and project subsidies and 28% structural government subsidies from the Ministry of OCW (Ministry of Education, Culture and Science)

Our Capital
Our building, our programs, our staff and our network are the essential ingredients for a successful future. With our transparent focus, well-defined priorities and smart investments, we use our capital to its full potential.

Iconic Building
The architect Renzo Piano's eye-catching, green-copper building on the waterfront has been a favorite among the public from the very beginning. It has become an icon in Amsterdam. In order to facilitate the growing number of visitors, we will create more space for the public by increasing the amount of floor space for visitors as much as possible. A new and more spacious restaurant will be built on the roof square that will also house an extra open-air museum floor. The museum entrance will be completely renovated so as to be able to receive all visitors in the best possible way and the NEMO shop will be expanded. All renovations are specifically directed towards a smooth flow of the public throughout the building, signposting and routing and the location of the various facilities. Extra attention will be paid to optimum lighting and acoustics in the museum. This way, we will enhance the experience for our visitors even more and sustain our programs for the future.

Coherent Program
NEMO's approach to exhibitions is highly successful, as is apparent from the large number of visitors. People enjoy our programs; they are active and they learn together. Our activities are considered accurate and challenging. They are interesting to a general public and they make science and technology accessible. Design and content of our exhibitions and programs are coherent. Moreover, NEMO's activities are varied and innovative. A new, comprehensive and inspiring story for the museum will enhance the experience for visitors even further. Each floor will be given an overarching theme; exhibitions will become more coherent content-wise and the number of exhibitions will be increased.

Motivated Staff
NEMO's staff is highly involved and motivated, with great passion for their work and their museum. They constitute our most important asset and they are going to help us realize our plans in the coming years. They contribute to our mission, vision, key values and strategic goals and also pass them on to our public and our collaborating partners. The cooperation within the organization is also of the highest importance and we stimulate this by means of an intensive training program. Those who guide the visitors through the museum are essential for the public's experience and they will continue to play a significant role in combination with the innovations in the museum. They encourage visitors to explore things on their own; they give theatrical performances, workshops and demonstrations, and they guarantee an excellent learning process and an enjoyable visit.

Extensive Network
NEMO's extensive network of partners and collaborating parties is of the utmost importance. NEMO and its partners take up a highly relevant position in today's society. Our network does not only provide us with financial and material support, but has also given us important professional advice for a great many years now. This way, partners from the business sector, funding organizations, schools, knowledge-based organizations, public authorities and the media do not only contribute to our unique program, but also to their own goals. Together we realize our objectives to interest the general public in science and technology from an early age onwards.

From Good to Great
For the purpose of ensuring a sustainable, even great future for our current successful museum, NEMO has formulated new strategic goals for the period 2014-2018. These goals are translated into five strategic initiatives.

Strategic Initiatives
The strategic initiatives will focus on higher quality and sustainable growth. This will take place in stages. The museum will remain open; the standard of quality of existing, successful elements of the museum will be specifically enhanced; visitor capacity will increase and exhibitions and the content of our story will gain further coherence. We will maximize our own strength and the expertise of our networks by participating with schools, science institutes and museum partners.

NEMO will realize its goals by means of five strategic initiatives:

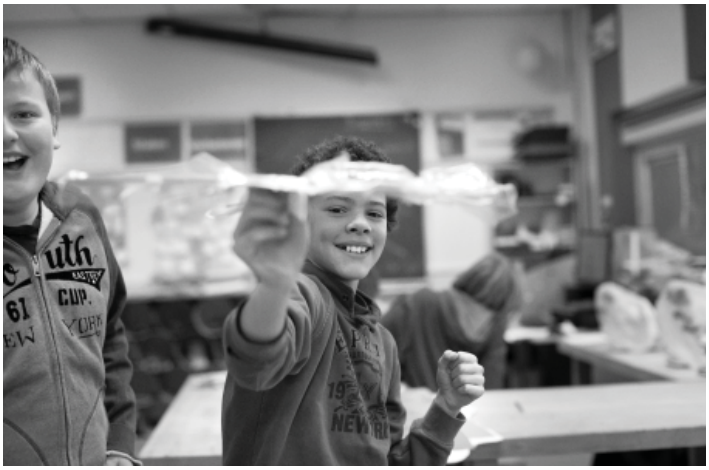
1. Fully renewed exhibitions with an overarching theme for each floor
2. A fifth open-air museum floor on the roof square
3. Supporting schools throughout the Netherlands in order to develop pupils' talents with respect to science and technology
4. A platform for the sciences and research facilities at NEMO
5. NEMO's technology collection, open to the public, will make young people appreciate technology

Strategic initiative 1: Fully renewed exhibitions with an overarching theme for each floor.
Visitors to NEMO will be presented with the basic principles of science and technology, so that they can more fully understand the world they live in. Three floors of the museum will be dedicated to the living, non-living and the manufactured world respectively. Next, one floor will be dedicated to the science fundamentals: phenomena and the scientific method. The story about the elements will be presented on the roof square. The exhibitions will be multi-faceted and be interesting for young and old. Objects from the legacy of our own collection and from the collections of fellow institutes will be included in our exhibitions. The active guidance by our staff, including hands-on workshops on each floor; improved restaurant facilities and a renewed museum shop will make a visit to NEMO more worthwhile and more interesting. The museum will offer its visitors an additional online service, thematically corresponding with the exhibitions. Our completely new website will thus become an online version of the museum.

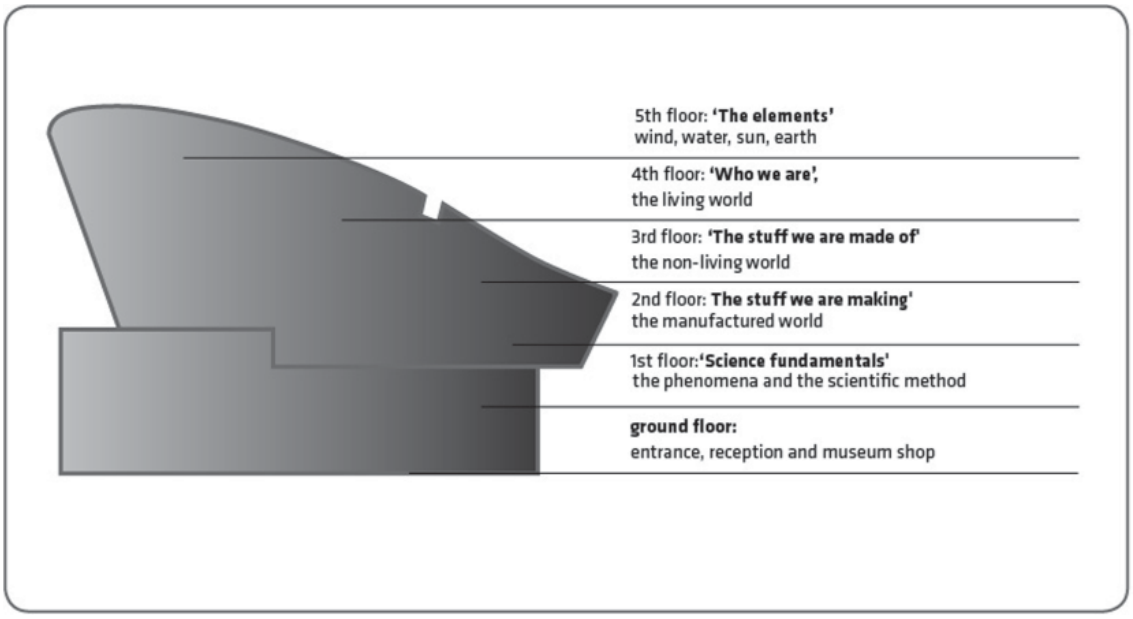
Although NEMO focuses on enhancing the visitor experience, the museum also intends to grow: from more than half a million to 600,000 visitors by 2018.

Strategic initiative 2: A fifth open-air museum floor on the roof.
The elements have free rein on the roof of the museum: wind, sun and water can freely play with the exhibits here. Renzo Piano designed the roof as an up-in-the-air city square for Amsterdam and his very first sketches show drawings of moving sculptures. The original ideas of the architect will now be realized.

The restaurant on the roof will be developed into a special NEMO restaurant that fits in with the visitor experience in the museum. The conservatory at the front will be enlarged and the interior of the restaurant will also become far more spacious. Presently, 60 per cent of museum visitors visit the roof. We would like to see this figure increase to 75 per cent. Aside from offering more space for visitors to the museum, the renewed roof facilities will annually result in 60,000 extra visitors who purposely want to visit the roof with its restaurant and its magnificent panorama.



Students participating in NEMO outreach activities



Floor by floor plan of NEMO

Strategic initiative 3: Educational support for schools throughout the Netherlands for the development of pupils' talents with respect to science and technology.
Ninety-five per cent of what we see around us has been invented and made by people. This is the indirect result of scientific research and technological progress. Because scientific and technological developments follow each other increasingly

faster, society is changing radically. We should prepare children for the 21st century, by teaching them the skills they need. These consist of creativity, problem-solving skills, collaboration and communication. NEMO is convinced that schools should pay greater attention to science and technology, with children learning actively by means of working with real materials. Hands-on activities are an important ingredient of interesting and inspiring education. Moreover, children can discover their talents for science and technology and develop them more fully.

NEMO professor demonstrating a museum activity

NEMO supports schools throughout the Netherlands by means of an educational trajectory, an additional curriculum, and teacher training. In a conservative educational landscape, dictated by commercial publishers, NEMO, being an independent museum, is a forerunner of educational reform. By 2018, NEMO will annually receive 100,000 pupils in the museum. By means of outreach programs, NEMO will reach twice this number of pupils in their own schools: 200,000 pupils annually, by 2018.

Strategic initiative 4: A platform for the sciences and facilities for research at NEMO.
For the general public, NEMO is the link with the sciences, even more strongly now than before. Scientists conduct research in the museum in cooperation with the public. Scientists also share their expertise with the public and enter into discussions with them.

NEMO Professor
The museum conducts research into learning about science under the supervision of Maartje Raijmakers, associate professor at NEMO's National Center Science and Technology/Science Center NEMO (NCWT/NEMO). She studies the circumstances from which children benefit the most when learning about science and technology. This way, NEMO and Maartje Raijmakers encourage children to develop their knowledge. The professor has a "laboratory" in the museum for conducting research in collaboration with visitors (children and their parents). NEMO also tests its own programs in this laboratory. The scientific method is therefore incorporated in our organization.

Kennislink "offline" in NEMO
NEMO's Kennislink.nl is a much-visited website presenting scientific information transparently by means of articles, themes and documents. Kennislink.nl is made by a team of 12 to 14 external editors, each with their own expert knowledge and their own scientific followers. NEMO is going to utilize this wealth of knowledge and insight more fully by organizing lectures and discussions in close cooperation with Kennislink.nl. As such, we offer our adult visitors new, interesting and up-to-date information.

Strategic initiative 5: NEMO's technology collection, open to the public, will show young people how fascinating technology is .
NEMO will set up a second location for technology in the north of Amsterdam. Our unique heritage collection will be housed in an open depot. Young people can now experience for themselves how fascinating technology is. The NEMO Heritage collection consists of more than 17,000 objects that illustrate the history of the relationship between man and energy, a concrete example of technological innovation. The workshops and educational programs focus on children from elementary schools, and teenagers from vmbo (preparatory middle-level vocational education) and mbo (intermediate vocational education). Moreover, the collection will be made digitally accessible, so that people can access our remarkable collection online.

Sustainable Future
By the execution of these strategic initiatives, we will enhance and deepen the experience of our visitors and sustain our programs and larger mission for the future. A renowned National Science Center in the Netherlands is no luxury, but a necessity. We will be able to face the challenges of the 21st century by means of science, technological innovations and a well-informed and well-educated population. Starting from a solid foundation, we want to play an even bigger role in society and increasingly become a relevant, trustworthy institute with a highly relevant public function.

1. Source: Top-55 museum visits, December 2012, Nederlandse Museumvereniging (Association of Museums in the Netherlands)
2. Source: Beerda continuous visitor research 2012, n=1,411
3. Source: BrandAlchemyTM, Day trip brand research the Netherlands 2012

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Renewing Technopolis®, the Flemish Science center

By Patricia Verheyden

Technopolis®, the Flemish Science center opened its doors to the public in February 2000. Our aim: to bring science and technology closer to the people. Our target audience: everyone in Flanders, the Dutch speaking region of Belgium with approximately 6.4 million inhabitants. Our tools: interactive exhibitions, shows, demonstrations, workshops and a whole package of outreach activities. In order to attract visitors on sunny days we opened a science garden in 2006. We also decided to develop exhibitions for specific target groups; this resulted in a children's area for young visitors 4 to 8 years old that opened in 2007. In 2009, after those two expansions it was time for a reflection. Who were we reaching with our efforts? How could we improve our services to our current audiences? Which new or under-served audiences should we do more for?

To find answers we started by looking at our visitors. On average Technopolis® had a yearly attendance of 300,000 visitors to the science center, reaching another 350,000 with outreach activities. The visitors to the science center can be divided roughly into two groups: one third of them come as school groups consisting mainly of children up to 14 years old, and two thirds as families. Also our outreach activities are mainly targeted to these groups. With the main exhibition and most of our educational activities especially attractive for the group 8 to 14 years old, and this group being particularly receptive for awareness around science and technology, it was clear that this group should stay our main target group and that we wanted to improve our offer for them.

In order to find out what people expect from Technopolis®, focus groups were organized with people outside the science center field, teachers and youngsters. And of course our scientific committee was consulted.

The following challenges were identified:
•the school curriculum for technology had recently changed, and some more changes were planned regarding science education.
•teachers were looking for help to adapt their lessons to the changing curriculum.
•youngsters aged 14 to 18 years old are less attracted by science and technology. Most of them have been in Technopolis® as a child, but they don't often return, although they are a very important group Those youngsters face important decisions regarding the choice of studies and the resulting career possibilities.

In December 2010 the board of directors decided that the three most important objectives for the future of Technopolis® were:
•to help teachers with science and technology education (there is a demand for this, as school curricula recently changed and teachers have difficulties meeting the objectives).
•to broaden the offer for our existing major target group and let them discover that science and technology are related to everyday life and important parts of many interesting and fascinating jobs.
•to reach the youngsters 14 to 18 year old and to try to get or to keep them interested in science and technology.

So the three important target groups were defined:
•teachers
•children 8 to 14 years old and their caretakers
•youngsters 14 to 18 years old

It was decided that we would create three new areas: one for each of these target groups in order to reach the following goals:
•improve STEM education in Flanders by helping teachers integrating the new school curriculum with interactive lessons
•to raise more interest for STEM related studies and careers in people of different ages

In December 2010 the Flemish government gave approval for the project, which was immediately followed by the commitment of the European Fund for Regional Development to contribute 40% to the necessary investment. In June 2011 the Flemish government approved a 44% contribution to the investment. Further funding came from the province and from industrial partners.

In spring 2011 a boost for the project was a call to the government by the Flemish parliament, the Flemish Education Council and the Flemish council for science and innovation where they raised an alarm about the low interest in STEM related studies and careers and the resulting problems for the future of our community. They all stressed the importance of the revaluation of STEM literacy. In July 2011 this resulted in a resolution where the Flemish parliament asked the Flemish government to set up an integrated

action plan on science and technology. In April 2012 this was followed by the organization of a General Assembly "Stimulation of Science and Technology" commissioned by the Flemish parliament.

When we were in the initial phases of this project I had the opportunity to take part in the Noyce Leadership Institute (NLI) program. As NLI focuses on the importance of community engagement it was obvious that our expansion plans should be my strategic initiative. Taking part in the NLI program from spring 2011 till spring 2012, while being in the middle of a major expansion, adding new types of activities, and reaching out to new target groups, was a challenge and an inspiration at the same time. NLI challenged me to think differently and gave me new insights that I could apply during the development of our expansion. The contact and support of my peers was invaluable and helped me through the hectic period.

In the meantime our team started working on the concept of the three new areas. Parallel architects and construction companies were preparing the construction of the new wing of the building. Construction of the building started in early 2012; installation of the exhibitions started in the beginning of 2013.

In May 2013 the expansion was officially inaugurated by the crown prince and princess. The following areas were created:

- STEM-center for teachers
- *Xplora* for children 8 to 14 year old
- *Inspirience* for youngsters 14 to 18 years old
    - *the Lab
    - *the Maker space

STEM-center for Teachers

Every year, more than 13,000 teachers and student teachers visit Technopolis®. These teachers are crucial in the development of the interest of youngsters in science and technology.

On one hand teachers stressed during focus group meetings their need for help in incorporating the changing school curriculum in their classes and in making their science and technology lessons more hands on. On the other hand different actors in Flanders are developing materials to help teachers with STEM teaching. However, those actors do not always cooperate and for the individual teachers it is very difficult to have an overview and find the materials that are most suitable for use in their classes.

Technopolis® therefore decided to offer teachers a permanent space where they can browse, try out and learn to use all types of educational material and resources that can help them with their STEM teaching. The materials offered in the STEM-center are coming from different actors in the field of STEM education in Flanders and are cataloged in a searchable publicly accessible database. This database is made as a part of an already existing database that is used by over 60,000 teachers (Flanders has approximately 120,000 teachers.)

The objectives of the STEM-center are: to inform teachers; to give them the opportunity to experiment with and to evaluate the existing materials; to educate teachers; to loan, rent or sell the materials to teachers; and to develop new materials.

***Xplora* for Children 8 to 14 Years Old**

This new 9,000 square feet exhibition is primarily designed for children 8 to 14 years old. These children are open to science and technology and are at a crucial stage of their life in which they make the first decisions that determine their further study and career possibilities.

Left, Xplora;
Bottom, STEM-center

The exhibition starts from imaginary and existing professions that appeal to the imagination of the children. It challenges the visitors to think about their potential: Am I creative enough for a career as climate maker? Is the job of tiger dentist for me? Would I be a good candy maker? Am I innovative enough for a job as an inventor? Is there an investigator or detective in me?

For each profession three to four interactive exhibits were developed and each profession has its own scenery, use of colors, and design. Next to the exhibits, information about real professions and real school disciplines is available. The information about real professions related to the imaginary profession is available through short movie clips featuring young professionals talking about their job. The information about possible school disciplines is given for different grades and types of studies.

Thus, the visitors discover that science and technology is not something that they just learn in school, but is something that they can use in real life, and even make an interesting career out of it.

All exhibits in this area are activated by a bracelet containing an RFID chip, and touch screens are used as labels next to each interactive exhibit. The first time a visitor logs on using the bracelet, he or she chooses the language (which they can change at any moment) and the visitor is asked some basic information: first name, gender, age and e-mail address. From then on, upon scanning their bracelet, visitors are addressed in the language of their choice and with their name. All results are stored in a central database, this allows visitors to keep track of their results (and how they performed in comparison to other visitors) during the visit, and later on the personal webpage which is being created automatically for each visitor. A mail with a link to this webpage is sent to the e-mail address provided by the visitor. At home they can see the information about the exhibits they experimented with, compare and share their results with those of others, and review the career and school curriculum information. To encourage them to come back and try out all exhibits, they also get a list of interactive exhibits they did not yet experiment with.

A returning visitor will receive a new bracelet, but by entering the same e-mail address as before they can add new data to their personal webpage.

For privacy entering an e-mail address is optional and it is possible to take part in all the exhibits without registering. In practice we observe that 70 % of the visitors enter their e-mail address, and that of this group 64 % take a look at their personal webpage.

An added advantage of the bracelet/touch screen system is that there is not a lot of text on the exhibits. As in Technopolis® all instructions are given in three languages and the amount of text on a printed label can quickly look like a lot of text. Using the touch screens and language selection by the bracelet we can show visitors only the text in their preferred language and with little bits at a time. Instructions are still kept to a minimum. Visitors who want to know more can press a more info button.

***Inspirience* for Youngsters 14 to 18 Years Old**

Before this expansion Technopolis® did not have an offer specifically dedicated for youngsters 14 to 18 year old. As several studies have shown, it is exactly this group which loses interest in STEM, we found it important to create a special area for them. Problem solving and creativity are core competencies for different parts of social life and many jobs. In *Inspirience*, a 4,500 square foot exhibition, young people and adults are inspired to do unique experiments using science and technology. They are challenged to use their creativity and create pictures and movies using technological equipment like a high speed camera, a setup with 40 cameras creating a short movie clip, a camera with a very long shutter time and a light pen. They can also experiment with different sound stations, light and shadow, magnetism. We encourage them to express their opinions, think about themselves, about their prejudices and preferences.

Inspirience

As in *Xplora* all exhibits are activated by a bracelet containing an RFID chip. Through their personal webpage they can then share the final result of their experiments, such as pictures and audiovisual files, with their friends via social media.

On school days this area is exclusively accessible for the groups of 14 to 18 year olds and their teachers. On family days (non- school days) Inspirience is accessible to all our visitors.

As part of this area two workshop rooms were developed: The Lab and a Maker Space.

The Lab

Not every school teacher is fortunate enough to have access to a fully equipped chemistry and/or biology laboratory. Because of this, some school children do not have the possibility to do hands on science experiments complementing their theoretical lessons.

Therefore Technopolis® created the Lab, equipped with ultra-modern equipment to perform hands on “wet“ science experiments as part of their biology and chemistry curriculum. The workshops offered in the labs were developed and chosen in collaboration with different partners from schools and universities. All the experiments were carefully selected, with aid of teachers, to not only complement the school curriculum but also to connect to the sphere of interest of the target group. For theoretical background

with the experiments a Cyber classroom is used with a 3D screen where molecules can be manipulated using a Wii controller. A workshop in the Lab takes 3 hours. Teachers can choose between workshops like nano sun screen, forensics, DNA research, coloring agents, etc.

During weekends and holidays the Lab is open to the general public, 30 minute workshops are offered to children aged 8 and up for simpler but exciting chemistry and biology experiments like making slime, extracting your own DNA.

The Lab

The Maker Space

With laser cutters and vinyl cutters, 3D printers and vacuum mold machines visitors can create two and three dimensional objects. Using simple electronics they can create objects that move or react to external inputs. The workshops in the Maker Space challenges participants to think, design and create. Key words are experimenting, failing, collaborative learning and learning by doing.

During the whole process from design to the realization of the product, visitors are helped and guided by a staff member, but they are also encouraged to learn from each other. Gradually they develop insight and technical skills.

The Maker space is open for family groups as well as school groups, each with a relevant offer, and also functions as a FabLab.

Impact on Staff

With the new wing the public space of Technopolis® increased by 33 %. Some of the activities we are now offering are new and quite different from the existing offer we had before the expansion: STEM-center, Lab, and Maker Space. Therefore the expansion resulted in reconsidering the organizational structure of Technopolis®.

In 2010 Technopolis® staff was divided over three departments: marketing, finance & operations, and experience. The finance & operations department had two subdivisions: accountancy and explainers. The experience department was divided into exhibits and edutainment.

In Technopolis® *explainers* are the people on the floor that welcome visitors, help them with exhibits. *Edutainers* perform shows, demonstrations, and give workshops to primary school children.

For the development of the new exhibitions it was clear that this was a task for the exhibits team, which was temporarily reinforced with two exhibit developers, one project collaborator and an additional technician.

We did not yet have a team for the development of the educational activities for 14 to 18 year olds in the Lab, Maker Space and for teachers in the STEM-center. To encourage the collaboration between explainers and edutainers, and to make it easier for explainers to grow into the job of edutainers, the edutainer team was moved to the operational department. The education team was set up as part of the experience department, several new staff members were hired for this team, and others came from the edutainer team.

Future plans

Since the opening in May 2013 tens of thousands of visitors tried out the exhibitions, and several hundred took part in the workshops. At the moment of publication of this article we are evaluating their feedback in order to further improve our offer. Thanks to the bracelets with RFID that activate the exhibits in both Xplora and Inspirience we have a wealth of statistical information that we can now start to analyze. For example, what are the most popular exhibits?, Are there differences between boys and girls? Between age groups? How much time do visitors spend on each exhibit and at what point do they leave the exhibit? Which exhibits are ignored by the visitors?

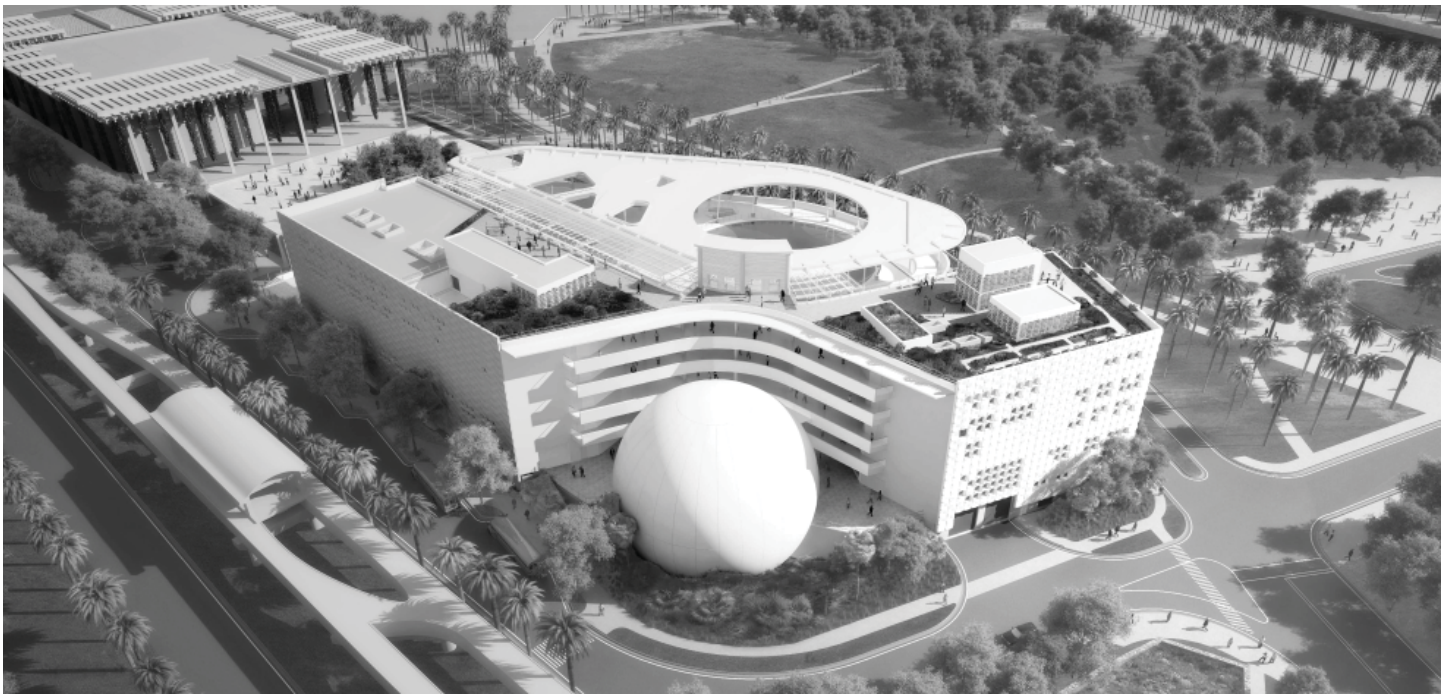
In the meanwhile we decided that from now on all new exhibits will be activated by the bracelet system and keep track of results. For low tech exhibits such as building an arch bridge it will only be the instructions on the touch screen that are activated by the bracelet. But even then useful information is available.

All of this is quite useful information to improve our exhibits and to take into account when developing new exhibitions. This is especially important as we are preparing the replacement of the main exhibition in several phases, a future process that will take some years to complete.

Patricia Verheyden is Experience Director at Technopolis®, the Flemish Science Center. She can be reached at patricia@technopolis.be.

The Patricia and Phillip Frost Museum of Science, Under Construction (date to Be announced)

By Sean Duran and Jennifer Santer



Schematic of the Patricia and Phillip Frost Museum of Science with the Perez Art Museum of Miami behind

Today is a pivotal moment in Miami's history – a time when civic leaders, businesses, families and individuals have joined together to create new cultural institutions that will reshape the image and the reality of this international gateway city. For over 60 years, the Patricia and Phillip Frost Museum of Science (previously the Miami Science Museum) has been making a difference in people's lives by inspiring them to appreciate the impact that science and technology can have on every facet of our world. Now, the legacy will continue with a new state-of-the-art facility designed by Grimshaw Architects, currently under construction in the heart of downtown Miami. The new Museum will support the innovation and creativity inherent in Miami's richly diverse community – inspiring dreams, raising aspirations and motivating people of all ages to discover new skills and enjoy the pleasures of learning.

The Museum will share the city's 40-acre Museum Park with the new Perez Art Museum Miami, creating a powerful cultural magnet in downtown Miami. The visitor experience will be structured around a lushly landscaped indoor and outdoor "living core" of terrestrial and aquatic environments, featuring a 500,000 gallon Gulf Stream aquarium experience, a full dome planetarium, the Knight Learning Center, the Innovation Center, interactive exhibits focused on many topics including the Everglades, health and wellness, aviation, evolution, as well as cafes and other amenities.

Over the course of development of the new museum, four members of the senior management team including two fellows and two sponsors, have participated in the Noyce Leadership Institute (Duran in Cohort Four and Santer in Cohort Six). Our strategic initiatives have fostered amongst the extended management team an externally focused mindset and have solidified the institutional value of community engagement. That culture has had a considerable impact on the conceptualization and development of the new building, assuring its key experiences and programs foster inclusion, accessibility, and equity.

From top to bottom, our new building will reflect our commitment to being externally focused, inclusive, and responsive to community's priorities and needs. As part of our intent to be a LEED-certified building, we're planning a green roof, except ours will not only include permanent plantings but also an urban food garden, with space for community groups to plant, grow, and learn the science

behind the latest growing technologies like hydroponics and aquaponics, and also learn about nutrition and healthy eating. Linking to this theme of community wellness, there will also be a building-wide fitness trail, starting in the outdoor Energy Playground at Plaza level, traversing our People & Science gallery, and ending up on the roof, responding to a key community challenge around heart healthiness and obesity.

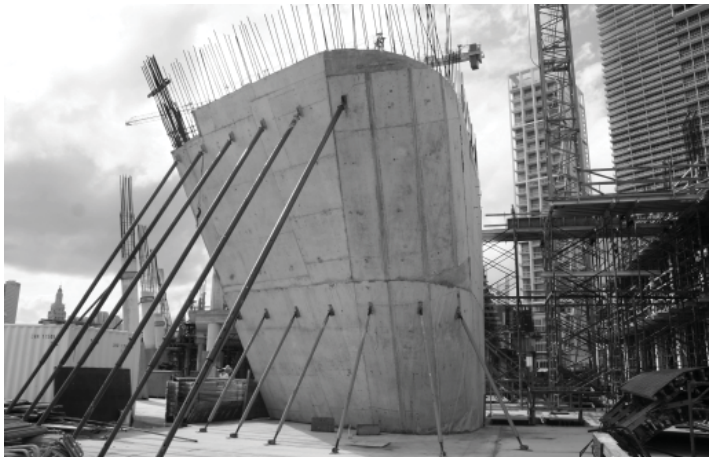
The Living Core aquarium, besides serving as a showcase for South Florida's wild and wonderful habitats, species, and the scientists who study them, will also be a recruitment point for volunteers who are interested in not only learning about, but doing something to help the environment. Over the past five years, a prototype coastal habitat restoration has already successfully restored more than 15 acres of coastal habitat, engaging over 3,000 volunteers, and is serving as a model for an expanded program of turning visitors into volunteers, addressing one of the community's most expressed needs for 'third spaces'.

The new Museum's Innovation Center is being conceptualized and developed in conjunction with corporate partners with a demonstrated commitment to local workforce development and capacity building, to unlock the creative potential of Miami's youth and young adults, positioning the Museum as a catalyst for innovation and economic prosperity.

As we approach a transitional period when the current facility will close prior to the opening of the new one, we are intensifying our efforts to develop a more distributed approach to our ongoing programs, ensuring our ability to continue to deliver on mission during our down-time. This is further helping us to think 'beyond our walls', and to develop and leverage partnerships with a wide range of organizations throughout Miami-Dade's diverse cultural community, ensuring that when we do re-open, we will have these strengthened ties, and a deeper understanding of our community's assets and needs, to inform our programming well into the future.

Sean Duran is Vice President, Exhibition and Design, and Jennifer Santer is Vice President, Content and Programs at the Patricia and Phillip Frost Museum of Science, Miami, FL. Duran may be reached at sduran@miamisci.org and Santer may be reached at Jsanter@miamisci.org.

This page: Ongoing construction at the Patricia and Phillip Frost Museum of Science
Next page: Schematic drawings of the completed Museum of Science




PATRICIA AND PHILLIP FROST
MUSEUM OF SCIENCE

The Hunt for Green Energy at Experimentarium

By Celia Ekelund Simonsen and Poul Kattler

Museums and science centers offer enjoyable hands-on experimental and inquiry-based learning opportunities structured in various ways and in various degrees that encourage curiosity and participation. These institutions are designed to support the freedom to explore topics and concepts within science (Gutwill & Allen 2012). However, the fact that museums and science centers are seen as places to learn does not guarantee learning, and it certainly does not ensure that visitors learn what is intended by the institution (Hein 1995); Not even when the visitors are students on a school trip. Open environments conducive to learning hold the learners as active participants and co-constructors of the situation, making it difficult, if not impossible, to predict the learning outcome or even ensure focus on a specific concept.

Museum educators (called pilots) at the science center Experimentarium in Copenhagen, Denmark have experienced exactly that dilemma in the school workshop 'Agents of Energy for a Day'. In response, Experimentarium decided to design a mobile application with three specific aims in mind: strengthen the connection between the workshop and the exhibit Energy; influence the students' use of the installations in the exhibit; and support the students' reflections on advantages and disadvantages associated with the production of green energy.

The mobile application was developed as a collaboration among the exhibition developers at Experimentarium, a PhD Fellow from University of Southern Denmark, and the research group Dream (Danish Research Centre on Education and Advanced Media Materials). Research was conducted in a workshop from August to December in 2011 in parallel to the design process, in a way that allowed for the knowledge from the user studies to inform the design.

In June 2012, Experimentarium presented the App 'The Hunt for Green Energy" targeting school children in fifth to seventh grade that visited the workshop.

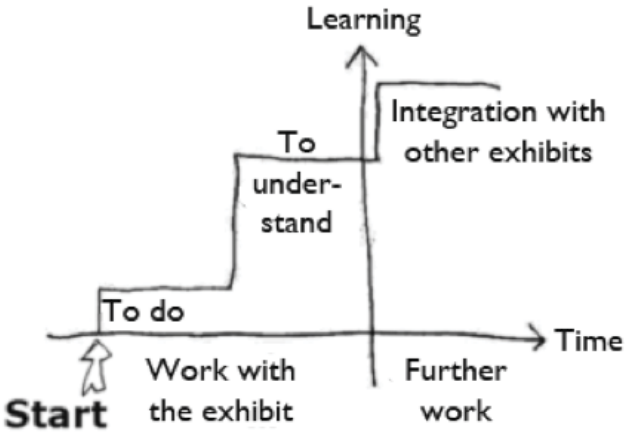
This article presents the considerations that underlie the concept and design of the App, and explores in what ways the use of a narrative and a smartphone on the exhibition floor help shape young people's learning through play in the school workshop Energy Agent for a Day.

The Challenge in Exhibition

Not unlike many other science center exhibitions, our *Energy* exhibit consists of installations established as simplified models of phenomenon found in the real world. The installations are made as stand-alone parts of the exhibit, and visitors are expected to interact with them: turn a handle, press a button or ride a bike to create electricity. This practical work is, generally speaking, very much a success, both with school visitors and with family visitors.

But how can learning happen in this environment?

We have identified some steps, which the visitors have to overcome in order to get the full and intended benefit.



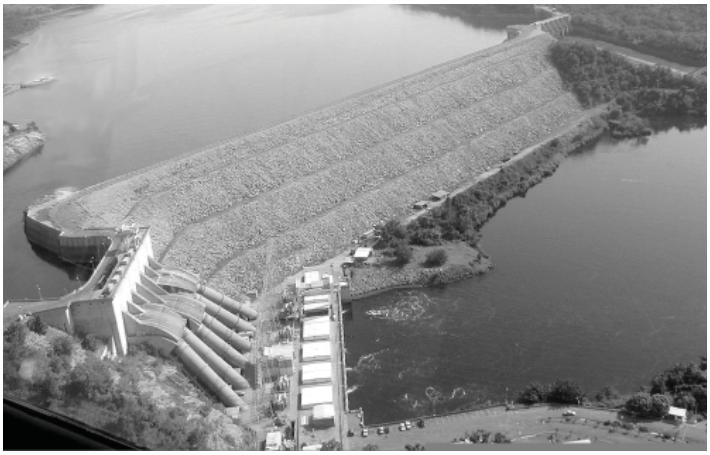
"To do" is quite simple. Students can rather easily take the expected actions. They can make physical things happen.

"To understand" or to learn is so much more challenging and is a process that we want our exhibit to support. Furthermore, the educational benefit of a particular design or exhibit component can often be lost on the causal museum visitor, despite our best efforts. For example, let's have a look at the Hydroelectric energy exhibit.

When visitors turn the handle, they pump water high to a reservoir – in the real world this is the water cycle: evaporation and rainfall. Visitors are acting as the rainfall!!

Next, visitors press a button to allow the water in the high position to fall down the drain and force a strange looking wheel to turn around, before the water reaches the base. A lamp at the dynamo is flashing, electricity is produced. Now they are acting as the power plant operator!!

Some youngsters can understand the model right a way. Some find the illustration next to the model a great help. But many will just pull the handle, and continue to the next



Left: the model at the Experimentarium; Right: the real-life power plant the exhibit simulates.

installation or exhibit.

Moreover the exhibits are clustered in a way where one exhibit adds learning to the next. 2 + 2 equals not 4, but 5. Green energy is not a standalone thing, neither are the exhibits about green energy. But will the learners see and benefit from this exhibition design?

Fact is, we as exhibition designers, were not satisfied.

App-narrative, June 2012: Aim of "Raiders of the Green Energy"

With this project we had a chance to change how visitors interacted with the exhibits.. We aimed to:

- •Support understanding of what the exhibit is about, by providing both user-instruction and extra background information
- •Link together exhibits that could support each other
- •Add in other elements outside of science and technology: i.e. society, moral, art etc.
- •Add a personal layer = YOU play a role
- •Create an opportunity to save userdata (mostly for the benefits of school classes post-visit)

The App-narrative Becomes a Part of a School Workshop

To make this happen, we took a chance and integrated more than one target group into the same solution. Our primary target group was 5th – 6th grade students (11-13 years) on a visit to our 2.,5 hour workshop named "Energy Agent for a Day". The App borrowed some parts from the narrative created to the workshop, so the Secretary of Energy who appears in the App is the same lady in both activities.

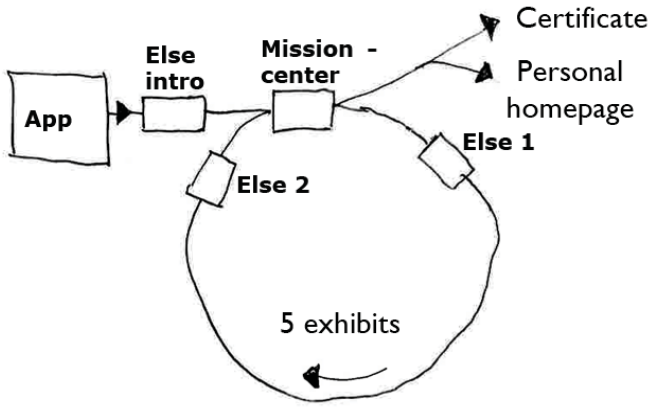
In addition, by presenting the App as a part of the general Experimentarium App we also present learning opportunities to classes who are not booking the school workshop.

All instructional material is published to all teachers on the website and all features at the App can be done regardless of our staff because the teacher can integrate the work in the exhibition in their classroom work.

The language in the App is Danish, limiting the use by most tourists, but a few international families have been observed using the App in the exhibition.

A Look at How the App is Used

The minister is looking for new field agents! Keep in touch with your commander and collect information from the field. Is green energy really something we can use in the future?



Within the App, the Minister Else Elstrøm is initiating the tasks with five exhibits, and the dialogue is maintained with the male voice, who is taking care of the information flow. Exhibits can be chosen as they become handy, and kids don't have to go to all exhibits in order to answer the questions and follow along.

Why do we think the App is a success?

1. *The kids are eager and engaged.* It is a good trick to use technology and the kids are confident and happy about!

2. *The kids are actually producing new results, and do make "real" contributions to the minister.*

3. *They are asking open-ended questions.* They determine that green energy is practical and they learn about the disadvantages that they can explore further in other parts of the exhibit. They discover that . the world is not only made for "yes" and "no" answers.

4. *Students know their work is important.* The results of each player's App are being stored and can be analyzed by teachers later in their classrooms.

Teachers Opinion: The App is Very Useful in the Exhibition and Afterward

This is feedback we have received from teachers, who took their classes to the workshop, and who evaluated the work with the App. They felt that the App:

•Raised the motivation of students considerably
•Was the student's preferred media
•Contributed to surprisingly high concentration in the exhibition
•Was easy to use, compared to paper and pencil
•Allowed better content understanding
•Made the exhibit personal and relevant
•Created ownership
•Created a bridge between work in the exhibition and work afterward

And What about the Work Back in the Laboratory? What Did we Learn?

•Students wanted their own contributions to be presented
•Their work was taken seriously, which is essential, when you are asked to work

Kids engaged in the exhibit using the new App on their smart devices

•80% of teachers claimed that the App did add value which could not have been obtained by the exhibition or the workshop separately

Conclusion

It was possible to create an App-tool, which could stimulate inspiration from the hands-on exhibition and bring it into the more classic instructor-students workshop environment. The power of modern handhold technology gives more patience to study, more ways of dialogue and more self-made products to bring further.

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The Science of Science Communication II

By David A. Ucko

Findings from the "science of science communication" continued to emerge at the second National Academy of Sciences Sackler Colloquium (September 23-25, 2013) addressing this topic. Although the focus remained "communication" rather than "learning" per se, those engaged in informal learning would do well to follow this growing body of social science research (Ucko 2012). Research in this field has been stimulated in part by challenges in communicating such topics as climate change, where simply providing more or better information may prove inadequate or counterproductive (Kahan et al. 2011). When addressing such complex issues, communication must take into account perceptual filters and "motivated reasoning" shaped by values, ideology, and other factors (Nisbet and Scheufele 2009, Scheufele 2013). Science communication research also has been stimulated by the Internet and social media, which have enhanced the ability of scientists to reach the public directly (de Semir 2010).

The following are selected remarks from the Colloquium, highlighting those most relevant to aspects of informal learning (with apologies to the presenters for any misinterpretation).

Audience and Society

1.Science communication must be informed by the target audience's culture, which shapes its cognitive processes

(e.g., how the world is perceived and knowledge gets organized). A mismatch or outsider perspective may undermine engagement and alienate. The term "public" is homogenizing. [Doug Medin, Northwestern University]

2. People are not idiots. Effective science communication requires both respect and trust. People trust others like themselves, who share the values of the group. Society's images of various groups can be characterized on a grid with the dimensions of warmth and trust. Scientists are stereotypically viewed as competent but cold, and therefore not trustworthy. Groups in this category of high competence/high status and low warmth/competitive are viewed with envy and jealousy. (In the same group are rich people, female professionals, lesbians, feminists, Asians, and Jews.) To overcome this bias, scientists should seek to form a warm relationship with the audience and share why they do science (not just for money,which is often viewed as their motivator). In addition, scientists should impartially communicate the science, including uncertainty, and avoid attempting persuasion on particular policies. In contrast to "cold" researchers, teachers are trusted because they are viewed more favorably as warm, so scientists should embrace a more 'teacherly' mindset [Susan Fiske, Princeton University]

3. Scientists should try to place themselves into the minds of a skeptical audience by connecting through simple stories that combine evidence with narrative; overcomplication often reduces credibility. Communicate "this is what we know" and how we reduce uncertainty. Tell the audience why you went into science to make your motivation explicit. Don't tell the audience what to do. [Bill Hallman, Rutgers University]

4. Social context matters. Affect and values influence beliefs, supporting the illusion of overconfident understanding and fostering an unconscious allure of in-group positions. As a result, minority views are often overweighted; "unpacking" can reduce their support. [Craig Fox, University of California, Los Angeles]

Social Networks and Media

1. Social networks can provide leverage to make possible scaling of science communication. Information obtained from media gets spread through opinion leaders. It is not only what you know that is important, but who you know (as well as what others think you know and who they think you know). Not all nodes in a social network are equal; seek to reach the touch points who serve as brokers or disseminators. [Noshir Contractor, Northwestern University]

2. The internet has made possible "mass personal communication" through platforms such as Twitter, which provides an observable flow of data for analysis. Nothing just goes directly "viral." Rather, those with many followers (e.g., celebrities, media, organizations, bloggers) can serve as "seeds" having a multiplier effect. Bloggers tend to do the most retweeting. One communication strategy is to target these intermediaries to reach large numbers of followers. [Duncan Watts, Microsoft]

3..The Internet has fostered a new ecosystem with flexible, software-based communication vehicles (in permanent beta mode), whose use evolves over time. Communication can be strategic with segmented messages that are targeted (e.g., Twitter). Twitter provides the social "soundtrack" of life in the moment. It is a social amplifier that provides a shared, dynamic, synchronous experience reaching large numbers that creates new connections and communities. Tweets are live, conversational, and public. Twitter can also point to deeper content and deliver targeted pieces of media. It can expand the experience of live events and change public perception. [Deb Roy, Twitter]

4. Based on research studies, the following are ways in which scientists can influence whether their research gets noticed and shared: highlight why it's useful; use emotional language (e.g., awe, anger, excitement); focus on what is interesting or surprising (to the public, not to other scientists); emphasize the positive. The research most widely shared is generated by social scientists; chemistry is the science least likely to be shared. The influence of peers, such as through Facebook friend "likes," creates social pressure to conform that can result in herd behavior. Differentiated use of social media can result in knowledge gaps, rather than "democratizing" information. [Katherine Milkman, University of Pennsylvania]

5. A breast cancer support network on Twitter (#BCSM) is an example of science communication that provides the latest research to a defined audience with highly motivated personal interest. [Xeni Jardin, Boing Boing]

Politics and Public Engagement

1. Science cannot be separated from politics in science communication. Most reality is constructed by media acting as a filter, setting the agenda and "priming" its audience. There is no such thing as unframed information; science is ambiguous and can be framed in various ways. Everyone uses "motivated reasoning"; the same information means different things to different people. Potential directions: connect science to everyday lives; provide accurate information; encourage diverse social networks; foster a new kind of "literacy." [Dietram Scheufele, University of Wisconsin, Madison]

2. Scientists comprise a Knowledge Generation community,

while science communicators are part of the Knowledge Transfer community; both inform the Policy Making community. Self-correction by scientists and science communicators help preserves integrity. Scientists should respect their audience, positioning both it and themselves as non-partisan. They should find common ground with their audience, building on what they already know using evocative narratives and clarifying metaphors. Scientists should disclose sources of funding and establish the integrity of the scientific methods used. They should inoculate the audience against partisan claims and discuss consequences of the science, but not make recommendations regarding implementation. [Kathleen Hall Jamieson, University of Pennsylvania]

3. The public should be engaged "upstream" on emerging science and technology, but doing so entails many challenges. They include lack of knowledge about the science, the risks, and the uncertainties. Determining who represents the public and how to frame the issue are critical. Ethical and social issues need to be addressed. An unanswered question is whether carrying out early engagement serves to prime the opposition. [Nick Pidgeon, Cardiff University]

4. Nanotechnology is not that different from other issues. The public asks the same questions: Who are the winners and losers? What are the risks? Who makes the decisions? Ethical, legal, and social issues are important to the public, not just risk. [Julia Moore, Pew Charitable Trusts]

Narrative

1. Narrative is a format of communication using a causally linked, temporal sequence of events involving specific human-like characters. The default human mode of thought, narratives are processed by a brain pathway that encodes situation-based exemplars vs. a paradigmatic pathway that encodes evidence-based arguments. Narratives are context dependent and begin with specifics rather than abstract generalizations. They are intrinsically persuasive and twice as likely to be recalled. Use of narrative raises ethical issues because they can be manipulated by presenting only one side of an issue. [Michael Dahlstrom, Iowa State University]

2. People are "suckers for narrative"; scientific discourse can't compete (e.g., drug ads that tell a people story vs. their boring technical medical disclaimer.) [Marty Kaplan, University of Southern California]

3. Narrative used in media can take advantage of vivid imagery and create immersion. Use of narrative can lead to a general understanding of a topic more likely to be remembered than isolated information. [Julie Downs, Carnegie Mellon University]

Science Communication

1. Less than $1 billion is spent annually on science communication, compared to more than $1 trillion overall for communication. To extend limited resources, transparent partnerships are needed with governments, NGOs, and corporations. Citizen science activities can foster "bottom-up" engagement of large numbers through use of smartphones, for example, to carry out relevant science related to one's body or environment. [Davis Masten, Quantified Self and Peter Zandan, Hill+Knowlton]

2. Most science communication is not actionable. If action is intended, it should be feasible, easy to visualize, remember, and do. The communication should be motivational and embed a trigger that specifies when to take action. An example is the "half a plate with fruits and vegetables" nutrition message. [Rebecca Ratner, University of Maryland]

3. What's new in science communication: social science research, network analytic methods, access to large data sets, computational infrastructure, greater networking. [Katherine Milkman, University of Pennsylvania]

4. Science communication research is "messy." Public opinion is difficult to determine; how each question gets asked affects the response. The public readily offers opinions on fabricated issues. It is also hard to know whether the public employs motivated reasoning or enlightened preference. [Patrick Sturgis, Southampton University]

For Further Information

The Colloquium agenda and videos of the presentations can be found at the following web site: http://www.nasonline.org/programs/sackler-colloquia/completed_colloquia/agenda-science-communication-II.html.

Published articles from the previous Sackler Colloquium are also available online: http://www.pnas.org/content/110/Supplement_3.toc.

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Funny Genus and Species Names

Abra cadabra (clam)
Agra vation (beetle)
Aha ha (wasp)
Ba humbugi (snail)
Colon rectum (beetle)
Enema pan (scarab)
Gelae baen, Gelae belae, Gelae donut, Gelae fish, and Gelae rol (fungus beetles)
Heerz lukenatcha, Heerz tooya, Panama canalia, Verae peculya (braconid wasps)
Ittibittium (mollusc) These are smaller than molluscs of the genus *Bittium*.
Kamera lens (microorganism)
La cerveza (moth)
La cucaracha, La paloma (pyralid moths)
Lalapa lusa (wasp)
Leonardo davinci (moth)
Oedipus complex (lungless salamander) Since renamed *Oedipina complex*.
Ohmyia omya (syrphid fly)
Phthiria relativitae (bombyliid fly) Since reclassified in the genus *Poecilognathus*.
Pieza deresistans, Pieza kake, Pieza pi, and Pieza rhea (mythicomyiid flies)
Pison eu (wasp)
Verae peculya (braconid wasp)
Villa manillae, and Reissa roni (bee flies)
Vini vidivici (lorikeet parrot)
Ytu brutus (water beetle)
Zyzzyva (beetle)

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On the cover:

The Noyce Leadership Institute (NLI) was created in 2008 to help prepare the next generation of leaders for science intensive museums, with a particular emphasis on gaining the skills and perspectives needed to increase the engagement of those organizations with their immediate communities.

In this special issue, five recent Noyce participants present papers on their experiences and resulting projects within their own museums. The photo on the right is Science Center NEMO in Amsterdam, home of NLI participant Amito Haarhuis.

Noyce articles begin on page 3.