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Inside: Evolution of University Museums

Plus: Virtual STEM Programs, Fostering Informal Residencies and MORE!

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Virtual STEM Programs at Public Libraries Featuring Scientists

By Anna Johnson, Carolina Chambers, Ginger Fitzhugh, Carrie Liston, Keliann LaConte, and Paul Dusenbery

A group of families gathers around a large screen at a public library as they get ready to meet three scientists at "Meet a NASA Scientist!" in Bothell, Washington. The on-site librarian and staff at the Oregon Museum of Science and Industry (OMSI) in Portland, Oregon have spent months collaborating with the scientists to craft the event. After a short introduction to the program and the scientists, the families move towards the edges of the room and locate themselves at stations where scientists, each calling in from a separate location in Oregon, await to speak with them. Each station is equipped with materials for a hands-on-activity, an iPad, and a speaker.

A young boy sits in front of an iPad while his dad stands next to him, listening carefully as his son asks a question about dwarf planets. The scientist, prepared for the types of questions he is hearing, refers to an image on the screen and guides the young boy through the hands-on-activity that helps explain how scientists like him detect planets that revolve around stars beyond our sun.

Figure 1. Library patron talking face-to-face over video with a scientist at "Meet a NASA Scientist!" program in Bothell, Washington.

As some families engage in conversations at the three stations, others explore additional activities while they wait for their turn to talk face-to-face over video with a scientist. Across the room, a young girl points a thermal camera at her dad, who is wearing a heated pad on his shoulder. Her mother smiles as she watches the iPad screen and observes how the color changes based on temperature readings from the thermal camera. After one hour of conversations with scientists and hands-on-activity exploration, the families gather back around the large screen for a final Q&A with all three scientists.

Figure 2. Library patrons exploring a STAR Net activity at "Meet a NASA Scientist!" program in Bothell, Washington.

Face-to-face conversations between scientists and public audiences in an informal learning environment provide a valuable opportunity to support public engagement with scientific research. These types of experiences have significant benefits for members of the public and for scientists. For public audiences, interacting face-to-face with a scientist can expand awareness of the range of careers in science, spark new questions about scientific topics, and increase interest in learning more about the scientist's topic (Tisdal, 2011; Ong, 2014). Scientists, too, are positively impacted by this type of public engagement (Storksdieck et al., 2017). Scientists who participate in public engagement training and programs report that their pedagogical

and communication ability and skills improve and that the experience is fun and rewarding (Tisdal, 2011; Ong, 2014).

However, in-person connections between scientists and public audiences are not always a feasible programming option. Scientists often live in urban areas, where universities, research centers, and private labs are located, while a large segment of the U.S. population lives in more rural locations (Health Resources & Services Administration, 2018). Typically, neither scientists nor individuals from rural communities have the time or resources to travel long distances to participate in programs. Virtual programming—in which a scientist is connected to public audiences who are geographically remote through a video-conferencing platform—may be able to help close this gap.

As part of the *NASA@ My Library* project, Pacific Science Center in Seattle, Washington implemented a pilot to test the feasibility and potential outcomes of one approach to virtual programming by developing and hosting programs for patrons featuring a virtual connection to a scientist at geographically remote public libraries. Central to this approach were collaborations between informal science learning (ISL) organizations and public libraries. The core components of our virtual programming model are shown in Figure 3. The pilot project sought to leverage the strengths and experiences of each of these two partner-types. Together, ISLs and public libraries worked to design, coordinate, and facilitate the virtual programs. Each brought unique expertise to the program development and served a specific role in planning and implementing virtual programs:

Public libraries play an essential and evolving role in their communities, supporting cultural engagement and serving as gathering places. They bring expertise in community engagement and lifelong learning. Increasingly, libraries are venues for STEM-rich learning experiences, with many librarians serving as facilitators of STEM learning.

ISL (informal science learning) organizations, such as science museums, zoos and aquariums, and planetariums, bring expertise in informal learning that is hands-on, interactive, and fun for all ages. Each of the ISLs that participated in this pilot project were members of the Portal to the Public Network (PoPNet), a community of practice dedicated to sharing ideas and strategies for scientist-and-public engagement (http://popnet.institutefor-

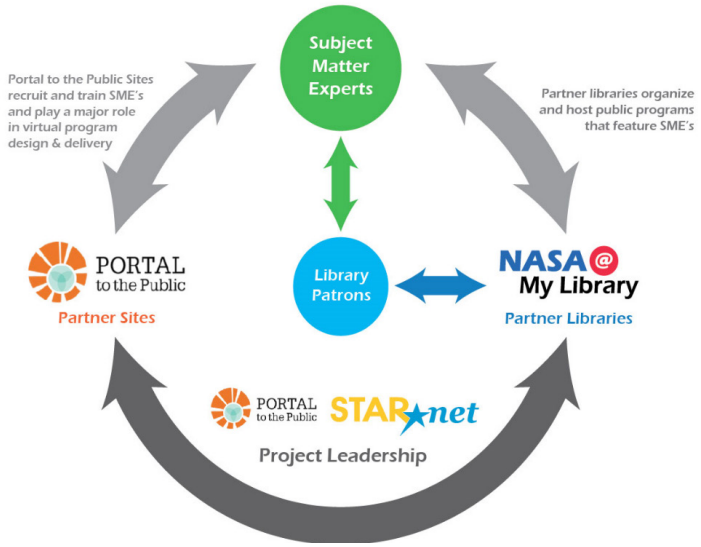

Figure 3. The pilot program was built on a collaboration between libraries that were part of NASA@ My Library, ISL organizations that were part of the Portal to the Public Network, and subject matter experts (scientists), supported by project leadership.

learninginnovation.org/). As members of PoPNet, the ISLs had existing connections with local scientists and scientific organizations, as well as experience in facilitating professional development with scientists.

An initial, eight-month pilot phase with two ISL organizations was followed by an expanded pilot phase with an additional four ISL organizations. With support from Pacific Science Center, each of the six ISL organizations partnered with at least one public library in geographically distant locations to develop, test, and refine virtual engagement strategies. Most ISL organizations partnered with several public libraries simultaneously (see Figure 4 and Table 1) to test multiple iterations of virtual programs.

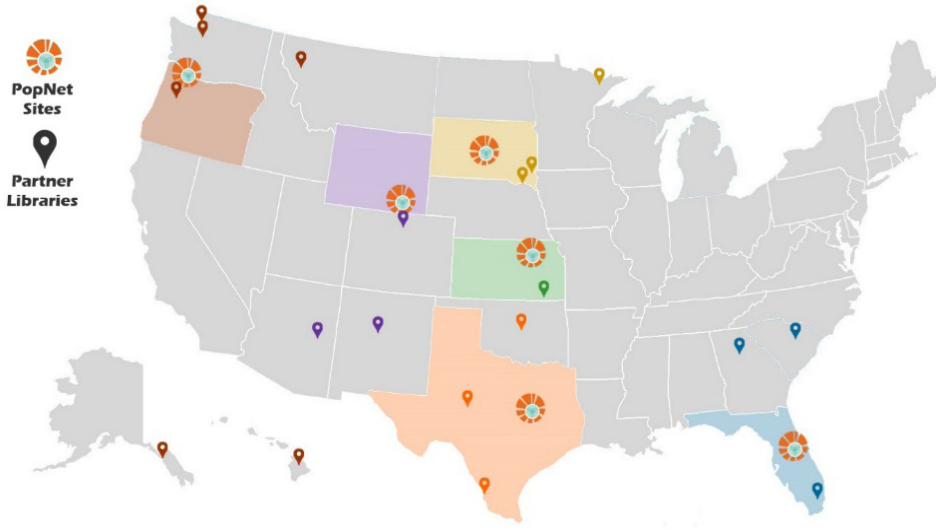

Figure 4. Map of participating PoPNet sites and library partners in the NASA@ My Library Project.

PoPNet Site	No. of Public Libraries Served	Total No. of Virtual Programs	No. of Scientists Involved
South Dakota Discovery Center Pierre, SD	3	6	4
Sunset Zoo Manhattan, KS	1	3	4
Wyoming NASA Space Grant Laramie, WY	3	6	5
Orlando Science Center Orlando, FL	3	6	4
Oregon Museum of Science and Industry (OMSI) Portland, OR	6	12	8
Mayborn Museum Complex Waco, TX	3	9	4

Table 1: A summary of the ISLs that were part of this pilot project and the number of libraries served, number of virtual programs, and the number of scientists that were engaged.

An external mixed-methods evaluation of both pilot phases was completed by Education Development Center (EDC). Data collection included surveys of representatives from ISL organizations, librarians, scientists, and patrons; site visits to a selected sample of programs (in-person or virtually, with an evaluator joining the online meeting); interviews with a sample of representatives from ISL organizations, librarians and scientists; and review of project documents, including monthly reflection forms by ISL organizations. Table 2 outlines which data were collected and the corresponding response rates.

PREPARING AND PLANNING VIRTUAL PROGRAMS

The ultimate goal of this pilot project was to connect scientists with library patrons in remote locations for high quality, engaging public programming about NASA science topics. Each ISL organization-public library collaboration aimed for the following characteristics within their virtual programs:

- Facilitation by a scientist or engineer who was prepared for public engagement through communication training.
- Opportunity for two-way dialogue between scientists and library patrons.
- Hands-on engagement that relates to the scientist's area of expertise, which provide a concrete opportunity for interaction and a starting point for conversations.

ISL organizations began the process by recruiting several scientists to participate. Each scientist was a subject matter expert in topics covered by NASA's Science Mission Directorate, and most were recipients of NASA funding. After recruiting scientists to participate, ISL organizations led the scientists through science communication and public engagement training, with a focus on preparation for virtual engagement in remote settings. Each ISL organization used Portal to the Public professional development training activities to ensure that scientists had some foundational grounding in public engagement skills. Participating scientists found the training to be valuable in preparing them for their virtual public programs: all scientists agreed they felt prepared to talk about their job to a public audience, 92% felt prepared to explain scientific concepts to a public

Data Collection Activity	Participation/ Response Rate
Patron Survey	Phase I: 72 total respondents; 4 programs at 4 different libraries Phase II: 276 total respondents; 14 out of 28 total programs at 9 different libraries
Site Visits	Phase I: In-person observation at 2 programs and Virtual observation at 2 programs Phase II: Virtual observation at 6 programs
Scientist/Subject Matter Expert Interviews	Phase I: 2 interviews with PoPNet-trained scientists/SMEs
Scientist/Subject Matter Expert Survey	Phase II: 13 Scientists/SMEs responded out of out of 22 invited from 5 PoPNet sites (4 or 5 scientists/scientists per site), a 59% response rate
Librarian Interviews	Phase I: 2 individual interviews with librarians (sample from the site visits) Phase II: 5 individual interviews with librarians
Librarian Survey	Phase II: 10 librarians responded out of 15 invited librarians (one per library), a 67% response rate.
ISL Organization Site Representative Interviews	Phase I: 2 interviews with representatives of the 2 PoPNet sites
ISL Organization Site Representative Survey	Phase II: 8 responses out of 9 potential respondents, 89% response rate; with respondents from all 6 PoPNet sites

Table 2. Evaluation Data Collection and Participation.

audience, and 85% felt prepared for the technical aspects of presenting virtually.

As part of their training, ISL organization staff supported scientists in selecting, adapting, or developing hands-on activities designed to help explain and facilitate a conversation around an important component of their work. Some scientists were guided in selecting a pre-existing activity, such as from STAR Net's STEM Activity Clearinghouse (http://clearinghouse.starnetlibraries.org/). Others, with coaching from ISL organization staff, crafted brand-new activities uniquely designed to represent or relate to their research. Unlike standard table-top activities, these activities needed to be facilitated through a screen, and required materials that libraries either had on-hand or were fairly inexpensive to ship. For scientists, who often have little experience in creating interactive educational activities for a lay audience, support from ISL organization staff was highly valued.

While ISL organizations were mainly responsible for scientist recruitment and training, the program design was a collaborative effort between ISL organization staff and librarians. Librarians shared critical information about the communities they serve and their interests, and communicated about the particular audience the programs could engage. Librarians also considered how virtual programs could enhance their existing STEM learning goals, since libraries increasingly offer a range of programs designed to support STEM learning. Some virtual programs were added

> "Honestly, the support from the staff at [our PoPNet site] has been amazing. Through this experience, I have gained invaluable experience in participating in outreach and public interaction with science."
>
> -Scientist Survey Respondent

into existing programs run by libraries, such as an ongoing Girls Who Code club. Others were set up as independent events.

The format of the programs developed by the ISL organization staff and librarians varied from place to place. In some, patrons experienced a brief presentation about a single scientist's area of expertise, followed by a related hands-on activity facilitated by the scientist. In others, multiple scientists called in to a single library to have virtual face-to-face conversations with patrons, as in the program arranged by OMSI and the King County Library System in Bothell, Washington, described above. The Wyoming NASA Space Grant at the University of Wyoming arranged a virtual lab tour of the Wyoming Infrared Observatory (WIRO) for library patrons, paired with astronomy activities and night-sky viewing on-site at the library.

BENEFITS OF THE APPROACH

"I think absolutely in-person visits are better, but I also know that I am a small town in the middle of [state]. Getting an expert to come here in-person is virtually impossible with the size of my programming budget. Having the ability to connect virtually, even with the drawbacks, is such a better option for our library, and the kids seem to be really excited about it!"

-Librarian Survey Respondent

Figure 5. Library patrons talking face-to-face over video with a scientist at one of the stations during "Meet a NASA Scientist!" program in Bothell, Washington.

The key players in this approach (scientists, librarians, and staff at ISL organizations) saw multiple benefits to conducting virtual engagement. Scientists reported that, as opposed to delivering in-person engagement, virtual programs allowed them to reach a broader audience and save on travel time and resources.

"I think the biggest benefit of engaging in these activities virtually is that we are able to reach so many people that do not have the direct access that living in a major city affords people. One of the events I participated in was [far away] and it was so amazing to be able to share my science with them...Virtual outreach presents so many unique opportunities for us to talk to people we would never have the chance to otherwise."

-Scientist Survey Respondent

Librarians, too, appreciated that virtual programming made a larger pool of scientists available to them, including those who were too far away or too busy to travel. For librarians without the time, experience, comfort, or connections to reach out to scientists to present a program, the role of the ISL organization (who recruited and trained participating scientists) was especially valuable.

Audiences and key partners alike felt like the programs were overall successful in meeting their intended outcomes of increasing public engagement and knowledge of Earth and space science. One concern related to virtual programs is their ability to form an engaging, personal connection between scientists and program patrons. Evaluation data suggests that, in this pilot, audiences generally felt connected to the scientist despite the virtual format. Nearly all of the patrons who responded to evaluation surveys indicated that the virtual connection with the scientist was engaging (98%). Similarly, the majority of librarians and scientists agreed there was a connection between the scientist and the audience despite not being in the same physical space. However, scientists were less likely than librarians to indicate that they felt connected to the audience. One scientist noted, "It is difficult to feel connected to an audience that I am speaking to virtually. Not being in the same room makes it difficult to read the body language and respond accordingly."

As part of a NASA-funded initiative, one goal of these pro

grams was achieving learning outcomes related to Earth science, space science, or engineering. Over 90% of patrons completing a post-survey indicated that they learned a lot at their virtual program, and the majority of patron survey respondents (83%) agreed that the program made them want to learn more about NASA science or careers. The hands-on activities were considered to be highly engaging and may have contributed to knowledge gains and increased interest in these subject areas. Most librarians indicated they appreciated the programs for the hands-on and more interactive portions, including how the activities effectively engaged different age groups. A summary of the benefits is described in Table 3.

> "We definitely learned a lot from doing virtual programs, including training scientists on virtual programs. I think this is a promising direction for our organization moving forward...."
>
> – ISL organization site representative

Stakeholder	Benefits
ISL Organization	Explored virtual programming and training scientists for virtual presentations Connections and experience working with libraries Reached expanded audiences with virtual programming (without travel time or expense)
Library/Librarian	Connections to scientists trained in engaging a public audience Increased comfort with STEM programming and programs with a virtual connection to a scientist Opportunity to connect patrons to a NASA scientist (without travel time or expense)
Scientist	Increased interest in public outreach Learned new skills for engaging audiences in science
Patrons	Engaged in science and hands-on activities Learned about Earth science, space science, and/or engineering Increased interest in learning more about Earth science, space science, and/or engineering and NASA science or careers

Table 3. There were benefits to conducting virtual engagement at every level.

CHALLENGES OF THE APPROACH

Despite the benefits of the approach, virtual programs, and in particular programs that rely on the involvement of multiple collaborators, bring challenges even to veterans of public programming. One of the most common challenges that arose for pilot sites were technical issues. Virtual programming relies on smooth technical operations at two or more physical locations, giving plenty of opportunity for technological problems to arise. Issues that arose included difficulty for the scientist seeing the audience, poor sound quality, and dropped internet connections. Technology issues were the most commonly cited response by patrons when asked about what they did not like about the virtual program.

Additionally, some participating scientists felt that they could have been better prepared for the technical aspects of facilitating virtually. Although the training they received from ISL organizations typically addressed pedagogical approaches to virtual engagement, it did not necessarily equip scientists with the on-the-ground knowledge and skills to navigate technical issues as they came up. This left some scientists scrambling when technical issues did arise during real programs.

Although technical issues may always be a challenge for virtual programs, some precautions can be taken to reduce the likelihood that they will negatively impact public programs. Ample opportunity for technology "test runs" with all partners, using the same equipment that will be used

during the program, can help detect issues with connectivity and audiovisual equipment. Clear communication around technical set-up may also help avoid issues; for example, making sure each person involved knows what equipment they are expected to bring and is familiar with how to use it.

For scientists, concrete practice with the virtual platform they will ultimately use in their program may be of great value in helping them feel prepared to take on the challenges of virtual outreach. For example, during a scientist training workshop, OMSI split scientists into two groups in separate rooms. Each scientist was asked to use the selected virtual platform (in this case, Zoom) to call another participating scientist in a separate room and practice facilitating their hands-on activity. Then, partners swapped. This simple exercise helped participating scientists both familiarize themselves with the operation of Zoom, as well as experience what it was like to be a recipient of a virtual program.

Maintaining smooth communication and collaboration between the various partners was also a challenge in the project. Some ISL organization staff learned that libraries

Figure 6. Scientists practicing virtual facilitation during OMSI's scientist training workshop.

may operate on a different schedule than their own organizations, needing to confirm event dates much farther out than the ISL organization was anticipating. Other ISL organization staff and librarians reported that because of the long amount of time between scheduling the program and delivering it, there was a lull in communication that affected the momentum of the project. Matchmaking schedules between the three main players - ISL organizations, libraries, and scientists - also proved to be a common hurdle. Thus, one major recommendation from the project is the need for partners to communicate all information possible, and communicate often. Libraries need plenty of time to get a program on the calendar, enough information to promote the program to patrons, and knowledge of how to facilitate the activity, if needed. Scientists rely on information about the patrons, space, and technical capabilities. Ensuring that all players have the information they need when they need it is critical to the success of the program and the partnerships.

CONCLUSION

Several projects, in addition to this pilot effort, aim to connect scientists with public audiences through a virtual connection. Skype a Scientist, which aims to help teachers bring scientists into their classrooms using Skype software, is one notable effort that facilitates virtual programming at a large scale. It is the hope of this project team that this pilot will add to the body of work around successful virtual programming, and build a case for components such as public engagement training for participating scientists, hands-on activities, and collaborations between ISL organizations and public libraries. The positive outcomes identified by evaluation data suggest that the approach is a valuable starting point for continued testing and refinement.

To support such ongoing testing, the *NASA@ My Library* project has created a practical guide for ISL organizations interested in creating their own virtual programs with scientists in collaboration with public libraries. The guide includes recommendations for preparing scientists for virtual programs, partnering with libraries, and navigating technical challenges. The digital guide is free to download and available at http://bit.ly/2BdrviM.

ABOUT *NASA @ MY LIBRARY*

This pilot project was a component of the larger *NASA@ My Library* project, led by the Space Science Institute's National Center for Interactive Learning (NCIL) and made possible through the support of the National Aeronautics and Space Administration (NASA) Science Mission Directorate (SMD) as part of its STEM Activation program. Through the *NASA@ My Library* project, NASA, public libraries, and state library agencies work together to increase and enhance STEM learning opportunities for millions of library patrons throughout the nation, including geographic areas and populations that are currently underserved in STEM education.

The project is designed to promote access to NASA science discoveries and provide learning experiences to persons of diverse backgrounds. NCIL--together with project team partners American Library Association, Cornerstones of Science, Lunar and Planetary Institute, and Education Development Center--leverage the STAR Library Network (STAR Net) to advance the NASA Science Mission Directorate (SMD) vision for education by engaging public audiences nationwide in informal and lifelong learning. *STAR*

Net focuses on helping library professionals facilitate STEM learning for their patrons by providing "science-technology activities and resources" (STAR) and training to use those resources (www.starnetlibraries.org). The *NASA@ My Library* team engages key stakeholders (e.g., NASA subject matter experts, public library partners, and state library partners) centered around high-profile NASA, Earth, celestial, and library events (e.g., 2017 solar eclipse, Earth Day, summer learning events at libraries). Key activities include stakeholder engagement, resource and experience development, professional development, a patron interest development research project, and a comprehensive project evaluation effort.

ABOUT PORTAL TO THE PUBLIC

The Portal to the Public Network (PoPNet) was an original partner of the *NASA@ My Library* project. The work described in this article was designed to build off of the Portal to the Public approach to public programming that is centered on connecting public audiences and scientists for conversations and activities. Created by Pacific Science Center, Explora, and The North Museum, and now led by the Institute for Learning Innovation, the Portal to the Public approach helps ISL organizations connect public audiences with current science in their own communities through conversations with local scientists and engineers. The Portal to the Public framework has been implemented at over 50 organizations that form the Portal to the Public Network (PoPNet), a community of practitioners dedicated to sharing ideas and strategies for scientist-and-public engagement. Through funding from the Institute of Museum and Library Services and the National Science Foundation, PoPNet has expanded to a range of informal science settings including science centers, museums, universities, zoos, aquariums, botanical gardens, and research organizations.

The Portal to the Public project developed a Guiding Framework ("framework") that organizations use to build programs that bring scientists and public audiences together for meaningful conversations and activities about science. The framework contains the building blocks needed to create a feasible, realistic science engagement project. It is intentionally flexible, giving each organization the ability to design and scale the specific approaches and strategies best suited to that organization's vision, community, and overall goals. The framework has been supported by research and vetted by the dozens of member organizations of PoPNet.

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On the cover:

The University of Michigan Museum of Natural History is one of three recently opened reconfigured facilities. Learn more about all three projects inside.
Full story on page 19.