© Journal of Higher Education Outreach and Engagement, Volume 25, Number 2, p. 111, (2021)
 eISSN 2164-8212

Science with Seniors: A Model Program for Senior Citizen–Centered STEM Outreach

Suyog Padgaonkar and Emily A. Schafer

Abstract

Many science, technology, engineering, and math (STEM) outreach programs focus on children, but relatively few efforts are dedicated to voting-age populations. These groups are important to reach because misinformation about science is widespread and difficult to detect, often interfering with informed voting on science-related issues. Science with Seniors (SwS) addresses this critical gap by bringing science research topics and news to the most dedicated voting demographic, senior citizens. Through SwS, graduate students and postdoctoral associates have delivered informal presentations on current and relevant science topics. Participating seniors have indicated that SwS has increased their understanding of the presented topics and that they would attend similar programs in the future. The article outlines a general program development methodology to support implementing this graduate student–led model elsewhere. Future directions include program expansion, additional online access, and evaluation of long-term effects on participants' voting habits and appreciation of science.

Keywords: science outreach, STEM, program development, graduate students, senior citizens

The relationship between Americans and their views on science is, in general, complicated. On one hand, the vast majority of Americans trust scientists and believe that investment in science pays off in the long term (B. Kennedy & Hefferon, 2019). On the whole, Americans' understanding of science has increased over time (National Science Board, 2018). At the same time, Americans have become increasingly susceptible to misinformation about science, a trend fueled by the growing significance of media and political polarization in recent years (B. Kennedy & Hefferon, 2019). The majority of Americans share views with scientists on most topics, but certain issues, such as climate change or genetically modified organisms, have seen large disparities develop between views held by scientists and those of the public (Druckman & McGrath, 2019; Funk & Kennedy, 2016). Alongside this troubling trend, surveys measuring public understanding of science reflect stark differences between age groups. More often than not, older adult Americans (aged 65+) tend to score lower on overall science knowledge than their younger counterparts (Funk & Goo, 2015). Independent of their performance on these science literacy tests, senior citizens tend to vote at much higher rates than other age groups. In 2016, over 90% of senior citizens were registered to vote, and over 70% turned out to vote, in contrast to just over 45% of Americans ages 18–29 (Bunis, 2018). Scientific information is important in informing policy, but misinformation can just as easily be used to create policies by influencing voters and public opinion. As a result, it is crucial that this highly dedicated voting group be properly informed about scientific issues, particularly those that have policy implications.

Scientists engage the public in two primary ways: direct outreach (through public talks, conversations, or interactive activities) and

citizen science (creating projects where the public can contribute with data collection or analysis). Although older adults have engaged successfully in a number of citizen science projects, this article's primary focus is effective program development for science outreach with senior citizens (Cronin & Messemer, 2013; King et al., 2016; Merenlender et al., 2016; Tuckett et al., 2018).

Currently, nearly all science, technology, engineering, and math (STEM) outreach efforts focus on increasing early interest in science among younger populations (children under 18; Andrews et al., 2005; M. Kennedy et al., 2017; S. Laursen et al., 2007). STEM graduate students are often eager to volunteer in such programs, motivated by intrinsic emotional benefits, a desire to enhance their teaching skills for career advancement, and the perceived ease and fun of teaching children (S. L. Laursen et al., 2012). These programs are often short-term and low-commitment endeavors for volunteers, involving brief lesson plans with interactive demonstrations, crafts, or other physical activities (S. Laursen et al., 2007). These outreach efforts aim to instill a love and appreciation of science early in childhood, reinforce broad skills for education, and inspire large percentages of students to pursue science-based careers (S. L. Laursen et al., 2012). Although this form of outreach is certainly important to build the next generation of scientists and emphasize informed science knowledge in all stages of life, it overlooks the general population of voting-age adults.

The most reliable voters in elections are senior citizens, yet to our knowledge, only two STEM outreach efforts have reported targeting this critical demographic. At the University of Missouri, the Science and Me program consisted of a novel 15-week course designed to train graduate students to build effective science communication skills. Over the course of 2 years, students who participated in this program gave 62 presentations and reached over 1,000 adults in independent living facilities, public libraries, and college reunions (Alexander et al., 2011). Feedback on these efforts was largely positive—audience members thoroughly enjoyed the chance to learn about current research topics, and students appreciated the chance to reach new audiences while improving their science communication skills. Another STEM outreach program that targeted senior citizens consisted of a series of monthly astronomy-related lectures to audience members in senior living communities in Rochester, New York (Rapson, 2014). This endeavor not only enriched the lives of seniors who grew up during a time when space science was a growing and popular field but also reminded participants of the importance of funding scientific research and related technologies. Importantly, this program built upon the work of existing lifelong learning institutes (LLIs) at its community partners, in which senior living communities or senior centers hold educational programs on various topics, such as yoga, cooking, travel, or literature. The overall goal of LLIs is to improve cognition (and prevent cognitive decline) by continuing to engage mental faculties of participants through intellectually challenging material (Simone & Scuilli, 2006). Additionally, LLIs promote intergenerational social interactions, prevent depression, and increase self-esteem and self-efficacy in decision-making processes (Brady et al., 2013; Lamb & Brady, 2005; Simone & Scuilli, 2006; Talmage et al., 2019). The work of such well-established LLIs as Osher LLI has demonstrated that the most effective facet of lifelong learning is promoting reflective judgment on existing beliefs so that these can be critically analyzed and independently revised if necessary (Lamb, 2011). An interactive learning format that encourages dialogue between the student and teacher promotes this type of reflective judgment.

Learning from the successes and challenges of these programs, an optimal science outreach program for older adults would both teach a wide range of scientific topics in depth to community members in a long-term sustainable manner and promote reflective judgment through interactive and engaging formats. Such a program should seek to build a framework that can ensure the most civically engaged demographic is scientifically informed by answering the following questions:

1. What are effective ways to engage senior citizens with science outreach?
2. How can senior citizens benefit from science outreach?
3. How does science outreach affect the attitudes toward science and voting habits of senior citizens?

Science with Seniors

In order to fill this gap in current outreach efforts and begin to answer these questions, we started an initiative through the Science Policy Outreach Taskforce (SPOT), a graduate student and postdoctoral associate–led organization at Northwestern University (NU) that is committed to advocating for science to policymakers and the general public. We (graduate student members of SPOT) have developed a model program called Science with Seniors (SwS), in which graduate students and postdoctoral associates from NU bring their expertise to local senior centers and offer brief, digestible science presentations on a variety of topics. Although we encourage NU presenters to relate their talk to current science news or policies to strengthen the connection between a basic understanding of science and governmental decisions, as a nonpartisan organization, we avoid expressing political opinions or telling participants how to vote in upcoming elections. Overall, SwS seeks to inform participants about science topics that impact our everyday lives, improve science literacy, and share an appreciation for scientific research and its outcomes, all of which can lead to more informed voting.

Program Development

To best reach this demographic, we chose face-to-face interactions in order to readily combat misinformation, which rampantly spreads online, with personal conversations (Jones & Crow, 2017; Scheufele & Krause, 2019). We developed SwS with a two-pronged approach to establish relationships with both community partners and presenters, as shown in Figure 1. To establish community partners, we contacted local senior homes to gauge interest in partnering with SwS. We then visited the partner sites to understand how our values align. After giving a trial presentation, we established a set of dates for presentations to take place and advertised these events at the partner site.

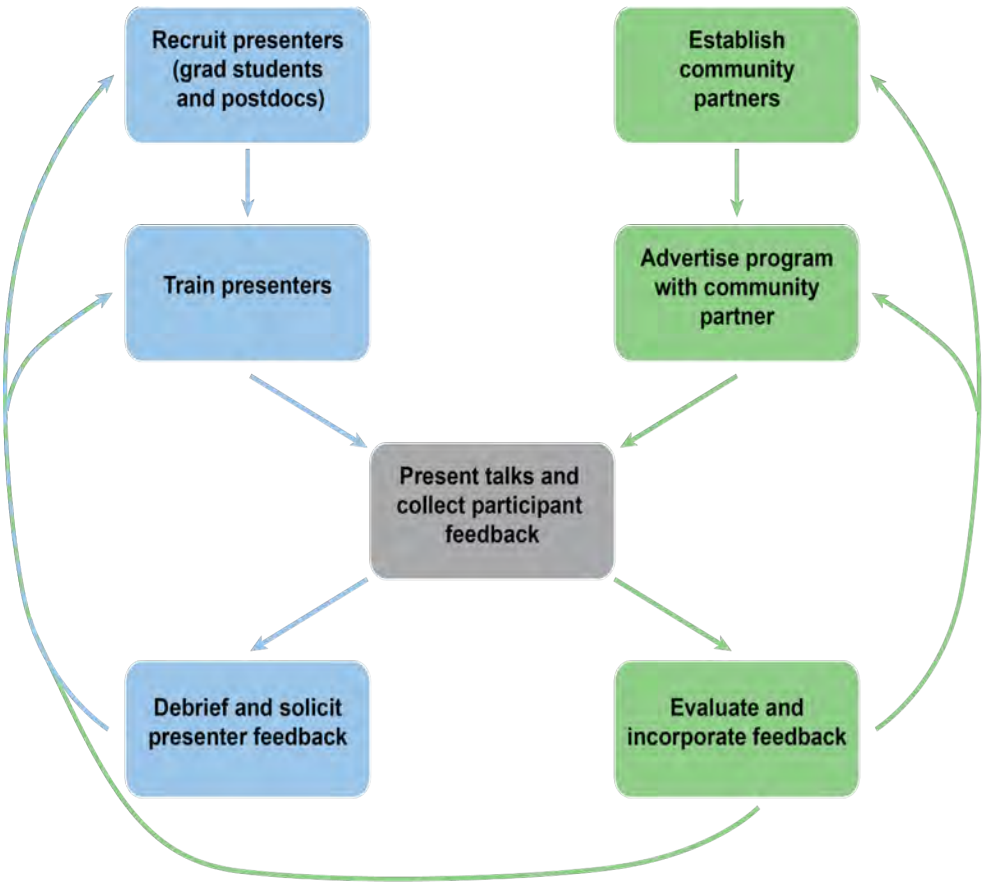

Figure 1. Program Development Steps for a Senior Citizen–Focused Science Outreach Program

Alongside these efforts, we recruited presenters (STEM graduate students and postdoctoral associates) at NU through information sessions. Many prospective presenters have experience with science outreach (primarily to children). They want to reach new audiences in the greater Chicago community and grow their science communication skills. We trained presenters by providing volunteer primers, which describe strategies for successful presentations as well as examples of past successful presentations. After presentations at the senior centers, we distributed surveys to solicit feedback from the participants to evaluate the program and continue advertising future presentations. Much of the feedback suggested future topics of interest, and we have recruited presenters with expertise in these topics. Other feedback about how the program could be improved, such as presentation style, has been incorporated in the training step. Expansion to new senior centers is possible after establishing a successful track record with the initial community partners. After the presentations, we also debriefed with the presenters and solicited feedback on how to improve the program from a presenter perspective. This feedback has been incorporated into the training and recruiting steps as well.

Community Partners

We established community partnerships with two local senior centers. In June 2017, we partnered with the Covenant Home in Andersonville, a northern neighborhood of Chicago. In December 2018, we partnered with the Levy Center in Evanston. The Levy Center population consists of independent community members since it is a daytime center; the Covenant Home is a live-in senior residential home. These populations differ in demographic makeup and cognitive capacity; however, we did not collect information on these aspects during the course of this program evaluation period because we used anonymized surveys to gather feedback. To build on this progress in the future as a science education research project, we would be interested in studying the differences in science literacy and overall understanding resulting from these presentations between the senior center populations and evaluating whether personal characteristics (age, education, gender, cognitive health) play a role in individual attendance and behavior.

Format

Our presenters consist of graduate students and postdoctoral associates who have demonstrated interest in our program by attending a recruiting information session. One or two volunteers sign up for a date to present, which occur monthly at each center, as seen in Figure 2. Our volunteers originate from a diverse range of STEM

Figure 2. A Graduate Student Presenting on Lab-on-chip Technologies to Seniors at the Levy Center, January 2019

Table 1. Advice for NU Volunteers

Frame the talk around interesting, engaging questions.	Keep in mind that these participants do not regularly attend science talks and may need to be persuaded that your content interests or relates to them. For example, "Why should you care about solar cells?" is more effective than "What are solar cells?"
Keep the presentation relatively broad and non-technical.	Give an overview of the topic and introduce the relevancy of this topic into the participants' lives.
Don't assume prior knowledge.	It is encouraged to define what scientists may perceive as simple concepts, even things like what the periodic table is and how electricity works. Some of the participants may not have formally studied anything science-related since high school 50+ years ago. Never use field-specific jargon.
Give historical context for your field.	Additional historical context and landmark events can help the participants connect more to the topic and your research. It also helps them appreciate the growth of your topic over time, and how far the field may have progressed.
Consider why they should know or care about the topic.	Think about these questions: Can they use it in their lives? Does it help people? Will their kids, grandkids, or future generations be impacted by it? As scientists, we may not test the relevance of your research in our daily lab work-life, but this potential impact is likely why the research is funded and how a lay audience can understand it.
Tie your topic to current news stories.	Many residents follow the news closely and will both understand more complex topics easier and remember the content of a presentation better if they can connect it to current events.
Connect your talk to policy.	Find recent policies, proposed budgets, recently introduced bills, or forthcoming policy changes that are relevant to the presentation. Explain the impact of policy on the field and how the participants can affect a change without endorsing any particular decisions, candidates, or political parties.
Make the presentation interactive.	Are there any props that may help increase understanding? Is there an interactive demonstration that could bring clarity to the narrative? Alternatively, consider creating a presentation that is primarily an interactive demonstration with an underlying message.
Be prepared to answer questions.	Don't expect to have all the answers, especially when they are unrelated to the field, but we as scientists are an advocate for science in general. We need to learn how to step out of our comfort zones and be willing to talk about science outside of our area of expertise. This program should be used as a time to practice and develop these skills.
Be sure to enjoy yourself!	The participants love talking to visitors. Being friendly and honest about your scientific knowledge also will show them that scientists are human too.

departments throughout the university, including chemistry, biology, physics, astronomy, earth science, materials science and engineering, medicine, biomedical engineering, sociology, psychology, and other departments. The topic that each volunteer chooses can be related to their scientific research or simply of interest to them. Presentations to date have focused on a variety of scientific topics, including brain–machine interfaces, lab-grown meat, antibiotic resistance, animal skin patterns, QLED TVs, climate change, MRIs, and more, again reflecting the broad range of subject matter studied by the NU volunteers that presented. Since the program's inception in 2017, we have had 54 unique presenters, with 31% of those returning to present more than once.

Our volunteers prepare 15–20 minute talks (typically in, but not limited to, a traditional slideshow format) with ample time for questions. We train the volunteers to refine the talks to be accessible for senior citizens. To help presenters prepare, we provide a volunteer primer with population-specific considerations along with sample slides from well-received presentations. The primer consists of tips that we consider vital for effective science communication to nonscience audiences, described in Table 1.

Methods of Program Evaluation

To understand the impact and effectiveness of SwS in its aims, we designed anonymized surveys that we distributed to participants after every presentation, as shown in Table 2. First, the surveys were designed to assess the degree of accessibility and communication of the content shared by the presenters. We asked if the presentations were helpful or engaging and if they increased participants' understanding of science topics. We not only received direct feedback on volunteers' efforts to communicate and engage participants effectively but also learned if presentations increased overall interest in science and willingness to participate in similar programs in the future. Another purpose was to understand the attitudes of participants toward scientific research and levels of civic engagement. Although anonymized feedback may lead to more honest feedback (Antonioni, 1994), one limitation is that we could not track individual behavioral changes over time. Future studies would benefit from collecting personal information to evaluate specific changes in participants' attitudes toward science and to determine whether participation in the program leads to perceived changes in voting behavior.

Outcomes and Feedback

Figure 3 shows that our program has been largely successful in its aims. Over the course of a year of presentations at the Levy Center (December 2018–December 2019), the survey feedback (n = 202) indicates that 90% of survey respondents agreed that presentations increase their understanding of the topic, and 92% indicated that they will return to the program. During the course of the 13 months of the presentations when these data were collected, we enjoyed steady attendance of 7–20 participants per ses-

Table 2. Sample survey given to participants at senior centers after presentations

Questions 1–5 were asked on a 5-point *strongly disagree–strongly agree* scale. Questions 6–7 were asked with a *yes–no* scale. Question 7a was open-ended.	
1	This program increased my understanding of the presented topic.
2	The presentation on the presented topic was helpful and engaging.
3	The presenters were knowledgeable about the topic(s).
4	Basic science is important and needs to be funded.
5	I am a consistent voter in local, state, and federal elections.
6	Would you be interested in further information on these topics?
7	Would you attend a similar program in the future?
7a	If yes, what scientific topics would you like to see covered?

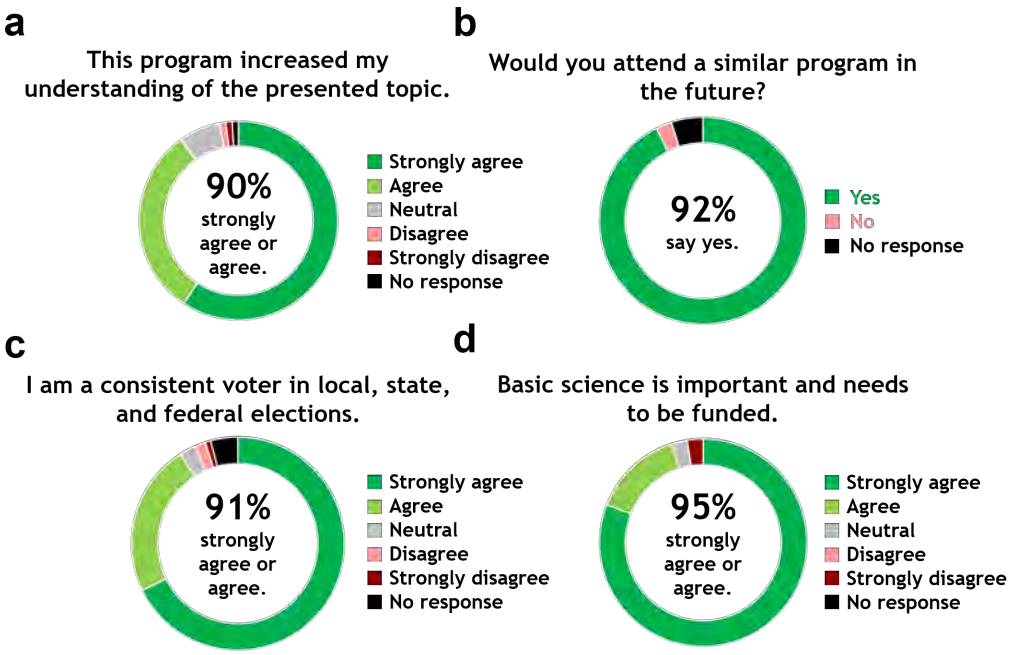

Figure 3. Survey Feedback From 202 Responses Collected December 2018–December 2019 at the Levy Center

sion. Feedback collected from the Covenant Home (n = 132) was largely similar to that of the Levy Center, indicating the overall generalizability of the program: 78% agreed that the presentations increased their understanding of the topic, and 83% reported that they would attend similar programs in the future. The disparity between levels of agreement in the two centers may stem from the demographic makeup and cognitive abilities. We suggest additional research to directly investigate this relationship.

To further examine the program's reach and its potential impact on voting and science appreciation as specified in the aims, we asked participants about their voting habits and belief in the importance of basic science funding. Although this measure did not explicitly probe the change in these behaviors as a function of the program, it did allow us to understand the opinions of the audience. We found that our participants consistently vote in elections (91% agree), which agrees with the expected voting rate for this age group nationwide. Finally, we found that our participants believe in the importance of basic science funding (95% agree), which suggests that participants who already have interest in science (and therefore positive attitudes about science) may be more likely to attend our sessions. This predisposition is an expected limitation, as our program is an optional event at each center. Future iterations of this program may include evaluation of how these results change in settings with less friendly preexisting attitudes toward science.

Lessons Learned

In creating SwS, we set out to answer the following questions:

1. What are effective ways to engage senior citizens with science outreach?
2. How can senior citizens benefit from science outreach?
3. How will science outreach affect the attitudes toward science and voting habits of senior citizens?

In the early years of SwS, we have been most successful at answering Question 1. Along the way, we learned several important lessons about this type of senior citizen–centered STEM outreach throughout its early years of development. Understanding the best way to tailor a talk to a given audience is crucial, and framing an argument is key in winning over an audience (Bubela et al., 2009). In early sessions of our program, we experimented with several formats to

understand which method works best. Some early talks tended to be too pedagogical and attempted to cover excessive detailed information. The result was a communication barrier between the presenter and the participants that prevented a productive conversation. Other early presentations tried to borrow aspects from STEM outreach and education designed for children, such as a number of interactive activities that involved mobility and dexterity (S. Laursen et al., 2007). Our training did not initially anticipate these population-specific considerations for an older audience, but several months of trial and error led to an optimal format.

We learned that the most useful format for everyone involved was informal talks with a large number of visual aids to reinforce complex concepts. As a result of this change, the participants have been consistently and highly engaged during sessions and have asked many questions throughout presentations. We encourage this type of interaction since it has marked a shift from a pedagogical to a conversational program. This type of interaction has led to successful outcomes in established LLIs because it promotes reflective thinking and more engaged learning (Lamb, 2011; Lamb & Brady, 2005). We are optimistic that this conversational approach of SwS will be similarly successful, although further research, as described below, will be needed to evaluate whether this format can lead to increased science literacy.

Additionally, we are starting new dialogues and forging new relationships that would not have been formed without SwS. Although our content has been primarily tailored to a lay audience level, we found that even participants with expertise in a certain area have been receptive to the content being presented. For example, a participant who was a retired biology professor was eager to contribute his own understanding on talks regarding CRISPR, GMOs, and antibiotics, leading to a productive and useful conversation where both parties learned something new. These talks are learning experiences for the presenters as well, and they often remark that the comments and unexpected questions that arise during the discussion portion of the session have led them to think about their research from a new angle and find clearer ways to answer questions. Frequently, participants asked questions that connected the presentation content to unconventionally related topics, such as news stories, personal accounts, and other types of science, leading to exciting new discussions. As a result, SwS sessions have evolved to become mutually beneficial dialogues for presenters and participants. One presenter summarized this sentiment, explaining,

> The prevailing mindset about seniors is that they can only understand so much. But my audience surprised me with so many technical questions and threw around terminology and technology that I had not heard of before. It was a learning experience that went both ways.

At this point, our program lacks a holistic answer for Question 2: "How can senior citizens benefit from science outreach?" Participating senior citizens have experienced a self-reported improvement in understanding of scientific topics, but there may be more benefits. As reported in prior LLIs, these types of lectures have the potential to improve cognitive ability, self-esteem, and overall well-being (Brady et al., 2013; Lamb & Brady, 2005). It would be interesting to understand whether SwS offers benefits beyond increased appreciation for science. For example, could these lectures be incorporated into a more holistic curriculum or integrated into other LLIs for maximum overall benefit?

Finally, further work is needed to rigorously probe Question 3: "How will science outreach affect the attitudes toward science and voting habits of senior citizens?" In this article, we have described the development of SwS as a sustainable STEM outreach program. A logical next step would be to establish a science education research project using SwS as a platform to investigate its role in science literacy and voting habits. Surveys before and after presentations could serve to measure changes in scientific understanding. This step could be further supplemented by asking questions addressing specific aspects of the topic to obtain a more accurate and non-self-reported way to probe scientific literacy. To date we have collected only anonymized feedback, but collecting personal information could enable us to track individuals' progress to measure long-term improvements in science literacy. To measure changes in voting behavior, which could be difficult to directly probe, we might ask supplemental questions after an

election to understand whether the presentations had any perceived impact on participants' decision-making process, especially about science-related issues.

With the results and lessons gained from SwS, we can put forth several recommendations to guide future STEM outreach programs that seek to focus on older adult populations:

1. Seek community partners with goals that align with program goals, such as established LLIs.
2. Spend the necessary amount of time on training presenters prior to sessions to maximize the potential impact of the content.
3. Make time to chat informally with residents before and after presentations to humanize scientists and build relationships.
4. Foster a dialogue between the presenter and participants by creating a comfortable space for questions and discussion.
5. Seek suggestions for program improvement from both presenters and participants.

Future Outlook

In addition to the methods outlined above to probe the original questions more rigorously, we plan on partnering with more senior centers and incorporating more medically related talks (which have been heavily requested) by recruiting more presenters from the NU Feinberg School of Medicine. Based on our success establishing this program in multiple locations, we are optimistic that this model can be expanded to other locations, such as public libraries or community centers, to reach a broader audience of voting-age adults. We are also in the process of making presented talks available online so that participants can access this information after the sessions and can continue the conversation about science elsewhere. These online resources would be accompanied by an optional online version of the survey to evaluate any learning that occurs beyond our direct presence. A long-term vision for this program is that these conversations will expand and proliferate beyond presentation sessions so that participants talk and think critically about science as they encounter it elsewhere in their lives, such as on the news or in the voting booth. We are exploring other ideas to build more actively engaging environments. These formats include distributing reading guides or case studies to participants beforehand and having participants lead small group discussions after presentations.

As an additional benefit, the SwS program improved science communication skills of the presenters. Although we did not explicitly measure this improvement during the early development of SwS, we have received unsolicited anecdotal feedback from presenters, along with the tendency for presenters to talk and take part in SwS multiple times: 31% of our presenters return to the program and give more than one presentation. As a result, we have recently begun to monitor this trend by distributing open-ended surveys to collect self-evaluations from presenters. Table 3 shows some early

Table 3. Presenter Feedback

"The prevailing mindset about seniors is that they can only understand so much. But my audience surprised me with so many technical questions and threw around terminology and technology that I had not heard of before. It was a learning experience that went both ways."
"I've been working on outreach for a while now and this definitely reinforced my belief in the importance of disseminating scientific findings to a broader audience."
"SwS has made me realize how important (and difficult!) it is to explain your research in accessible terms and to make the topic exciting/relevant to others. I also feel more confident in my speaking skills!"
"It really showed that sci comm is much more versatile than I generally think—you truly do have to cater it to audiences."
"I realized that outside of classrooms and scientific conferences, it's important to take a step back from detailed explanations and focus more on what research has accomplished and why it is important."

feedback from presenters from personal experiences with SwS.

Academic education of graduate and postdoctoral researchers tends to emphasize research communication to peer scientists over presentation skills for lay audiences. By presenting with SwS, volunteers gain valuable communication skills and experience for tailoring science talks to people with a wide range of science backgrounds. Providing these tools to early-career scientists and engineers will advance the urgent task of continuing to grow the network of scientifically literate voting-age people. The communication skills that presenters develop during SwS sessions are likely to help them in future outreach events and in professional contexts beyond science outreach (S. L. Laursen et al., 2012).

Finally, we plan to encourage more general feedback about the program to further improve SwS. By engaging all participants, including presenters, in shaping the program, we can meet mutual needs and increase the program's impact on the community. We hope that SwS will continue on its path of sustainable long-term growth while being viewed by the NU community as a useful learning experience valuable to all STEM researchers and by the broader community as a trustworthy, accessible, and engaging program.

Acknowledgments

We are grateful to the Society for Science & the Public for a STEM Action Grant, the Materials Research Science and Engineering Center at NU (supported by the National Science Foundation under NSF Award Number DMR-1720139), and the Graduate School at NU for their generosity in supporting SwS. We are deeply indebted to the helpful staff and enthusiastic participants at the Covenant Home and Levy Center for their willingness to facilitate and attend this program. We are thankful for the many graduate students and postdoctoral associates who volunteered their time to give presentations. The Science in Society program at NU was especially helpful for early conversations about program development and community building. Finally, we appreciate the support of SPOT members and advisors in creating and sustaining this program.

About The Authors

Suyog Padgaonkar *is a doctoral candidate in chemistry at Northwestern University.*

Emily A. Schafer *is a doctoral candidate in biomedical engineering at Northwestern University.*

References

Alexander, H., Waldron, A. M., & Abell, S. K. (2011). Science and me: A student-driven science outreach program for lay adult audiences. *Journal of College Science Teaching, 40*(6), 28–34.

Andrews, E., Weaver, A., Hanley, D., Shamatha, J., & Melton, G. (2005). Scientists and public outreach: Participation, motivations, and impediments. *Journal of Geoscience Education, 53*(3), 281–293. https://doi.org/10.5408/1089-9995-53.3.281

Antonioni, D. (1994). The effects of feedback accountability on upward appraisal ratings. *Personnel Psychology, 47*(2), 349–356. https://doi.org/10.1111/j.1744-6570.1994.tb01728.x

Brady, E. M., Cardale, A., & Neidy, J. C. (2013). The quest for community in Osher Lifelong Learning Institutes. *Educational Gerontology, 39*(9), 627–639. https://doi.org/10.1080/03601277.2012.734147

Bubela, T., Nisbet, M. C., Borchelt, R., Brunger, F., Critchley, C., Einsiedel, E., Geller, G., Gupta, A., Hampel, J., Hyde-Lay, R., Jandciu, E. W., Jones, S. A., Kolopack, P., Lane, S., Lougheed, T., Nerlich, B., Ogbogu, U., O'Riordan, K., Ouellette, C., . . . Caulfield, T. (2009). Science communication reconsidered. *Nature Biotechnology, 27*(6), 514–518. https://doi.org/10.1038/nbt0609-514

Bunis, D. (2018, April 30). The immense power of the older voter in an election. *AARP Bulletin*. https://www.aarp.org/politics-society/government-elections/info-2018/power-role-older-voters.html

Cronin, D. P., & Messemer, J. E. (2013). Elevating adult civic science literacy through a renewed citizen science paradigm. *Adult Learning, 24*(4), 143–150. https://doi.org/10.1177/1045159513499550

Druckman, J. N., & McGrath, M. C. (2019). The evidence for motivated reasoning in climate change preference formation. *Nature Climate Change, 9*(2), 111–119. https://doi.org/10.1038/s41558-018-0360-1

Funk, C., & Goo, S. K. (2015). *What Americans know and don't know about science*. Pew Research Center. https://www.pewresearch.org/science/2015/09/10/what-the-public-knows-and-does-not-know-about-science/

Funk, C., & Kennedy, B. (2016). *The politics of climate change*. Pew Research Center. https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2016/10/PS_2016.10.04_Politics-of-Climate_FINAL.pdf

Jones, M. D., & Crow, D. A. (2017). How can we use the "science of stories" to produce persuasive scientific stories? *Palgrave Communications, 3*(1), 1–9. https://doi.org/10.1057/s41599-017-0047-7

Kennedy, B., & Hefferon, M. (2019). *What Americans know about science*. Pew Research Center. https://www.pewresearch.org/science/2019/03/28/what-americans-know-about-science/

Kennedy, M., Daugherty, R., Garibay, C., Sanford, C., Braun, R., Koerner, J., & Lewin, J. (2017). Science Club: Bridging in-school and out-of-school STEM learning through a collaborative, community-based after-school program. *Science Scope; Washington, 41*(1), 78–79.

King, A. C., Winter, S. J., Sheats, J. L., Rosas, L. G., Buman, M. P., Salvo, D., Rodriguez, N. M., Seguin, R. A., Moran, M., Garber, R., Broderick, B., Zieff, S. G., Sarmiento, O. L., Gonzalez, S. A., Banchoff, A., & Dommarco, J. R. (2016). Leveraging citizen science and information technology for population physical activity promotion. *Translational Journal of the American College of Sports Medicine, 1*(4), 30–44. https://doi.org/10.1249/TJX.0000000000000003

Lamb, R. (2011). Lifelong learning institutes: The next challenge. *LLI Review, 6*, 1–10.

Lamb, R., & Brady, E. M. (2005). Participation in lifelong learning institutes: What turns members on? *Educational Gerontology, 31*(3), 207–224. https://doi.org/10.1080/03601270590900936

Laursen, S., Liston, C., Thiry, H., & Graf, J. (2007). What good is a scientist in the classroom? Participant outcomes and program design features for a short-duration science outreach intervention in K–12 classrooms. *CBE—Life Sciences Education, 6*(1), 49–64. https://doi.org/10.1187/cbe.06-05-0165

Laursen, S. L., Thiry, H., & Liston, C. S. (2012). The impact of a university-based school science outreach program on graduate student participants' career paths and professional socialization. *Journal of Higher Education Outreach and Engagement, 16*(2), 47–78. https://openjournals.libs.uga.edu/jheoe/article/view/933

Merenlender, A. M., Crall, A. W., Drill, S., Prysby, M., & Ballard, H. (2016). Evaluating environmental education, citizen science, and stewardship through naturalist programs. *Conservation Biology, 30*(6), 1255–1265. https://doi.org/10.1111/cobi.12737

National Science Board. (2018). Science and technology: Public attitudes and understanding. *Science and engineering indicators 2018* (NSB-2018-1, Chap. 7). National Science Foundation. https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-technology-public-attitudes-and-understanding/public-knowledge-about-s-t

Rapson, V. (2014). Reaching for the stars in your golden years: The importance of outreach for senior citizens. *Communicating Astronomy With the Public, 15*, 18–19. https://www.capjournal.org/issues/15/15_18.php

Scheufele, D. A., & Krause, N. M. (2019). Science audiences, misinformation, and fake news. *Proceedings of the National Academy of Sciences, 116*(16), 7662–7669. https://doi.org/10.1073/pnas.1805871115

Simone, P. M., & Scuilli, M. (2006). Cognitive benefits of participation in lifelong learning institutes. *LLI Review, 1*, 44–51.

Talmage, C. A., Hansen, R. J., Knopf, R. C., Thaxton, S. P., McTague, R., & Moore, D. B. (2019). Unleashing the value of lifelong learning institutes: Research and practice insights from a national survey of Osher Lifelong Learning Institutes. *Adult Education Quarterly, 69*(3), 184–206. https://doi.org/10.1177/0741713619834651

Tuckett, A. G., Freeman, A., Hetherington, S., Gardiner, P. A., King, A. C., & On Behalf of Burnie Brae Citizen Scientists. (2018). Older adults using *Our Voice* citizen science to create change in their neighborhood environment. *International Journal of Environmental Research and Public Health, 15*(12), Article 2685. https://doi.org/10.3390/ijerph15122685