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Training scientists in a science center improves science communication to the public

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THE LANGUAGE OF SCIENCE is inherently academic and often inefficient in its delivery of key concepts to nonscientists (10a). When President Obama spoke at the National Academy of Sciences in April 2009 (15b), he issued the following call to think of new ways to engage young people in science, mathematics, and technology: “I want to persuade you to spend time in the classroom, talking and showing young people what it is that your work can mean, and what it means to you . . . think about new and creative ways to engage young people in science and engineering . . . to be makers of things, not just consumers of things.” To reach the next generation of innovators, scientists must become better communicators, clearly informing and inspiring the public about their research (14). The training of scientists to participate in outreach has been primarily focused on formal education settings and working with K–12 teachers (12, 18). For example, in response to government agencies encouraging and, in some cases, requiring the integration of research, education, and outreach, the Space Science Institute (Boulder, CO) developed an annual 4-day workshop for scientists, which included 27 presentations on teaching science in schools and 1 panel discussion on engaging scientists in education through public outreach (15).

Many programs place volunteers in classrooms and impact science literacy in the community (5). However, learning outside of the classroom in informal settings such as science centers often marks the beginning of curiosity in, and can significantly enhance the public understanding of, science (10a). These types of informal education opportunities outside the K–12 classroom, with audiences that can include adults, are less frequent, likely because scientists are unaware of the existence of such opportunities (1). Additionally, because of their informality, science centers provide an excellent opportunity for researchers to discuss their work in everyday, non-technical language, which has been shown to improve the understanding of science concepts (7, 8). To date, most studies have examined the motivation of and challenges facing scientists participating in such outreach (1, 10, 13, 16). One study (13) of informal outreach conducted at public science fairs in Madrid, Spain, noted that the scientists involved were often encouraged by their senior colleagues to participate, while those senior scientists often felt a sense of duty to do such outreach. However, any lasting effect of participation in outreach on those scientists’ attitudes, as well as their effectiveness in science communication to the public, has not been thoroughly examined.

To address the challenges of recruiting, training, impacting, and retaining scientists in informal outreach and to capitalize on access to the public through a local science center, Washington University and the St. Louis Science Center (SLSC; http://www.slsc.org) collaborated to create a program that combines informal science communication and the professional development of graduate students. The program sought to produce scientists who were trained to be effective informal educators. Workshops developed and led by SLSC staff, followed by personalized coaching, covered essential science communication skills and culminated with a student-driven capstone project. Program evaluation showed significant benefits for both the public and the scientists. The public perceived an increased understanding of science and of scientists. The scientists reported improved views of science outreach.

METHODS

Program development: a model to foster science communication skills. In 2005, several Washington University faculty members invited SLSC staff to design a science communication component for a soon-to-be-submitted National Science Foundation (NSF)-Integrative Graduate Education and Research Traineeship (IGERT) proposal. The general goal of the component was to train an annual cohort of graduate students in the cognitive, computational, and systems neuroscience (CCSN) pathway (ccsn.wustl.edu) to present general brain science and, in particular, their research to a large public audience, such as that of the science center. Not only would this program benefit the graduate students, but it would also bring current scientific research and processes to science center visitors.

Concurrent with Washington University’s invitation, the same SLSC staff was involved in a growing number of Public Understanding of Research (PUR) initiatives within the Association of Science and Technology Centers, all encouraged by the NSF. Key among them was the seminal, invitational conference, “Museums, Media and the Public Understanding of Research,” (9) and collaborations that grew out of the conference (e.g., Robotic Research in the Public Eye, Nanotechnology Informal Science Education Network, Portal to the Public, and others). After the NSF-IGERT proposal was funded in 2006, SLSC staff learned that Chicago’s Museum of Science and Industry (MSI) had begun a similar program, MSI SciTech Chicago Outreach Pilot Exploration (MSCOPE), 6 mo earlier; it was the first such program in the United States. Serendipitously, one of the MSCOPE participants joined the SLSC evaluation staff in year 1 of the IGERT grant, contributing valuable program experience.

The Science Communication for Brain Scientists program combined PUR techniques with existing training used for new SLSC staff. The program offered hands-on training, modeling, and personalized coaching in workshops. The workshops reviewed how scientists have been involved historically in PUR, who the “publics” are, face-to-face...
introductions to the audiences, general principles of how to reach these publics, an overview of the strategies (exhibit and program design) used in science centers, practice in front-end and formative evaluation, and areas of convergence in communication tools used by science centers and by scientists (e.g., scientific posters, National Institutes of Health language initiative, and talking with nonspecialist colleagues). To engage the students in their professional development through this science outreach training, students participated in the workshops in the SLSC so that they could easily move between the private meeting room and public exhibits. Additional incentives included free membership in the SLSC, meals during the presentation dates, and admission to special public lectures and the opening gala for SciFest.

**Learning goals.** The learning goals of the Science Communication for Brain Scientists program were crafted by SLSC staff, Washington University faculty, and CCSN graduate student representatives. These goals were stated as follows:

- Introduce graduate students to the field of informal science education and its approaches to science communication.
- Provide graduate students opportunities to develop and deliver educational experiences about their research for the SLSC’s general public audience while working closely with SLSC staff members.
- Enable graduate students to understand the significant gap in knowledge and language that exists between specialists and lay audiences in different settings.
- Assist graduate students in identifying and improving their audience engagement skills through observation, experimentation, and practice.
- Provide graduate students with professional development that will enable them to communicate effectively about their scientific research and its importance with a large and varied public.

**Cohort experience.** The training program (Fig. 1) required graduate students to present their research to the public. Evaluations gauged the perceived impact on science understanding in the community and graduate student professional development. Students from three graduate programs (Psychology, Biomedical Engineering, and Neuroscience) were invited to participate in this training. Students self-selected to participate in the workshops and agreed to present at two events during the year. Funds were used exclusively to support salaries for the SLSC staff and to cover the costs of supplies for the exhibits. An initial group (cohort 1) of eight PhD candidates in neuroscience, psychology, or biomedical engineering participated. Students played a major role in the initiation of this program. The incentives to participate were primarily encouragement from faculty members and their peers. Participants had free access to SLSC exhibits and special events during the year but did not receive graduate credit, certification, or stipends. Training began with three 4-h workshops led by SLSC staff over consecutive weeks in the summer on the topics of audience, language, and presentation tools. These workshops included presentations, hands-on activities, small-group work, and discussion. For example, the Language Workshop included a lecture and hands-on demonstrations about effective and ineffective terms used in public signage. Workshops were followed by several hours of interaction with visitors in the SLSC to gauge visitor interest in brain science topics and develop a set of capstone projects. Once the capstone projects were identified, SLSC staff provided guidance on exhibit and program development, layout, and text and labeling.

**Cohort 1** designed and built an integrative brain science event with hands-on activities and displays describing student research topics. Taking a page from the television series “The Real World,” they worked with SLSC staff and a graphic designer to create a “house” with neuroscience themes [titled “The Real World–Neuroscience” (RWN)]. For example, the “kitchen” had visitors eat jellybeans with and without holding their noses. The graduate student running the activity studies olfaction and explained to visitors how her research applied to an everyday experience, like eating a meal. Each of the six activities throughout the house was designed similarly to educate the public about the students’ current research interests in the context of the real world. In addition, a 10-min video featured a laboratory tour and an interview with each student. The video, which looped continuously throughout the event, provided a glimpse into the world of a graduate student.

**Evaluation methodology.** Evaluation activities addressed the impact of the training on the graduate student participants as well as the effectiveness or impact of their program for SLSC visitors. Key questions were as follows:

- What are the students’ incoming levels of familiarity with informal science education? How does this change over the course of the training?
- What are the students’ incoming comfort levels with presenting current science to nonscience audiences? How does this change over the course of the training?
- Given the optional nature of this component of the grant, what are the students’ motivations for choosing to participate?

![Timeline of training in effective science communication to the public. This short program guided cohorts of graduate students through workshops and culminated with an interactive educational program at a local science center. The three 4-h workshops and two day-long presentations (SciFest and NeuroDay) were held at the St. Louis Science Center (SLSC), typically on weekends. Students designed, built, and refined their presentations on their own schedules. The graduate student participants demonstrated improvements in science communication.](image-url)
• What new skills do the students successfully apply in the development and delivery of their educational program(s)? How do they envision applying them in their professional careers?
• How effective are the students in communicating about the brain to SLSC visitors?

Evaluation of this training program used multiple methods. Participating students completed pre- and postworkshop surveys (Supplemental Material, Supplemental Form 1), participated in brief, open-ended interviews immediately after delivery of their program at SciFest, an annual multiday science festival (http://scifeststl.org), and at NeuroDay, a day-long brain science expo at the SLSC as part of National Brain Awareness Week, and completed followup surveys at the conclusion of the year. Interviews were used to gain knowledge of the cohort experience to help shape the training program for future cohorts.

At both SciFest and NeuroDay, visitors to RWN and the Amazing Brain Carnival (ABC) were invited to complete surveys as they exited the room (Supplemental Material, Supplemental Form 2). At each event, a randomized selection of visitors were invited to complete the survey. Approximately 10.5% of visitors completed surveys, averaged across the four events, RWN attracted ~600 participants at both SciFest 2008 and NeuroDay 2009. ABC attracted ~400 visitors during SciFest 2009 and >1,200 visitors during NeuroDay 2010. Sample sizes for participant feedback collected at each of the four offerings were as follows: SciFest 2008, n = 55; NeuroDay 2009, n = 36; SciFest 2009: n = 68; and NeuroDay 2010, n = 116.

The SLSC has been a leader in the informal education field in developing and implementing tools to assess the impact of its educational programs. As one of many possible evaluation tools, the SLSC currently uses their System for Assessing Mission Impact (SAMI) to evaluate its broad suite of educational programs (11). SAMI is designed to assess the impact of educational programs on participants based on the SLSC’s definition of “impact,” where impact results “... from a Science Center offering that enables a participant to make a personal connection between the content and experience of the offering and their own knowledge and experiences. In the short-term, this is illustrated by a change in knowledge, understanding, attitude, interest, or enjoyment.” The development and refinement of SAMI has occurred over several years, with its earliest incarnation preceding the publication of seminal works such as Learning Science in Informal Environments, published by the National Research Council (NRC) (9a), and Evaluation Frameworks (15a), published by the NSF, by several years. SAMI thus provides a measure of impact similar to tools used in other publications (17).

SAMI feedback forms (Supplemental Form 2) incorporate closed-ended questions on a four-point scale that address each of the key elements of the SLSC’s definition of impact: knowledge, enjoyment, interest in science, and attitude toward science. The sum of the response scores to the four questions is referred to as the impact score (IS), which can range from a low of 4 to a high of 16. Individual answers are scored as 1 (“no, not at all”), 2 (“only a little”), 3 (“quite a lot”), and 4 (“yes, definitely!”). The standard wording for the questions is as follows:

- Did you, or others in your group, learn content and/or skills from this program?
- Did you enjoy this program?
- Did this program make you want to try another experience with science or technology?
- Did this program reinforce or increase any positive attitudes you have toward science or technology?

As applied to the evaluation of the science communication training program, slight modifications were made. For surveys given to visitors, the references to “program” were edited to specifically refer to the program the graduate students created, either RWN or ABC. For surveys given to the graduate students, references to “program” were clarified to “training program” and references to “science or technology” were edited to refer to “science communication.”

In addition, participating students were asked to describe their motivations for participating in the training and to reflect on their familiarity with informal science education and their comfort with presenting science to the nonscience audiences. Participating visitors were asked to describe what they learned about the brain and to rate their engagement with the graduate student presenters in addition to responding to the SAMI questions. Responses to these open questions were not statistically analyzed but were used by the SLSC trainers to guide future events and workshops. We found that the measures of impact on the public and the graduate students were highly similar between the 2 yr of this study. Here, we focus on comparing the overall IS (scored from 4 to 16) of RWN at SciFest and NeuroDay in years 1 and 2 with the overall ISs of five other informal science events at the SLSC and on comparing the measures of comfort in presenting to the public and familiarity with the scientific concepts (both scored from 1 to 4) in years 1 and 2.

RESULTS

Impact of RWN on science knowledge and perceptions of scientists. Cohort 1, a group of eight graduate students, five of whom were in at least their third year of their studies, premiered RWN in October 2008 during SciFest 2008. Approximately 600 visitors attended during the 5-h session. Evaluations of 42 adults and 13 children revealed an overall IS for this first presentation of 14.27 (of 16). When cohort 1 delivered their interactive exhibit again in March 2009 during NeuroDay, the IS was 14.78 (n = 32 adults and 13 children surveyed). In comparison, visitors who experienced other aspects of NeuroDay (e.g., lectures and demonstrations), but not RWN, had a significantly lower IS (13.25, P < 0.01 by one-way ANOVA). The combination of both offerings of the program yielded an IS of 14.50, which was higher than the overall collection of all educational programs offered by the SLSC in 2009 (IS of 13.89). Programs offered by the SLSC in 2009 that featured presentations by science content experts to nonscience audiences provide another comparison. The Family Med School program, which featured family-oriented hands-on activities, had an IS of 14.34, comparable to that of RWN. The Science Café program, in which science experts lecture about their research to adult audiences, had an IS of 13.55, significantly lower than RWN (P < 0.01 by one-way ANOVA).

Survey respondents indicated a perceived understanding of the students’ research and more about scientists and the scientific process. For example, at NeuroDay 2009, visitors to cohort 1’s RWN were asked to describe how well they understood the students’ research. The mean rating was 3.4 of 4, with 47% selecting the highest rating from the choices of “don’t understand at all” (1), “sort of understand” (2), “understand pretty well” (3), and “understand very well” (4).

Evolution of the model: cohort 2 and ABC. The year after cohort 1 completed the program, a second group of nine students (cohort 2) completed the summer workshop series and developed a novel educational program for SciFest 2009. Unlike cohort 1, the majority of cohort 2 had only completed 1 yr of their graduate studies when the summer workshops

1 Supplemental Material for this article is available at the Advance in Physiology Education website.
began. ABC featured new hands-on activities and drew >400 visitors. Surveys indicated that this program had a lower IS (13.30, n = 47 adults and 21 children, 17% of visitors) than the initial presentation of RWN (P < 0.03). The relatively higher impact of the first cohort may have arisen from its more established students, with greater prior presentation experience. Importantly, as with cohort 1, the opportunity for students to refine and repeat their presentation as part of NeuroDay 2010 raised the IS (14.17, P < 0.02), based on 69 adults and 47 children surveyed from the >1,200 visitors who entered the ABC room.

NeuroDay 2010 provided another opportunity to examine the continued influence of science communication training on interactions with the public. Three graduate students (two students from cohort 1 and one student from cohort 2) plus six other graduate students, two postdoctoral fellows, and one faculty member presented a series of neuroscience demonstrations for SLSC audiences. The IS for demonstrations presented by the students from cohorts 1 and 2 was 14.04, which was higher than for other motivated scientist volunteers (13.80 for graduate students, 13.00 for postdoctoral fellows, and 13.70 for faculty members). Thus, 25 h of training and project development in science communication positively impacted the audience understanding of scientific content and perception of scientists and demonstrates improvement in the effectiveness of student communication after such training.

Impact on graduate students: improved familiarity and comfort. Through the survey feedback collected before the workshops, after twice delivering their program, and finally 1 yr later, students showed increases in their self-rated familiarity with informal science education and comfort with presenting science to nonscience audiences. Table 1 shows the students’ mean rating (out of 4) with regard to their familiarity with informal science education (differences over time were significant at P < 0.01 by a paired-samples t-test). Table 2 shows their mean ratings (out of 4) with regard to the comfort with presenting science to nonscience audiences (differences over time are significant at P < 0.02 by a paired-samples t-test).

DISCUSSION

Model strengths and areas for improvement. A major priority of any successful outreach program is to train and retain scientists as public advocates for research and science literacy. The primary reason that this program appealed to busy graduate students, and thus motivated their participation, was by focusing on their professional development and opportunities to discuss their research with the public. Additionally, exit surveys show that student presenters found their training for and involvement in SciFest and NeuroDay increased their interest in further opportunities for science outreach. Students indicated they were “extremely interested” (mean of 3.5 of 4) in future neuroscience presentations at the SLSC. Balancing training time with graduate students’ busy schedules played a role in this; students preferred summer workshops, when classes were not in session. Continued participation was higher for students who had completed at least 2 yr of graduate study but declined as students approached graduation. First-year and fourth-year students cited the time commitment as their primary reason for withdrawing. We conclude that students in the middle stages of their graduate careers are most likely to complete professional development and continue participating in science outreach.

Specific training in science communication augments scientists’ impact on public understanding of science and perception of scientists. As shown from the students’ feedback, the ability to effectively communicate content improves with repeated presentations (Supplemental Data–Responses). While the SLSC staff provided guidance and tools, ultimately it was the graduate students who educated visitors about brain science and informed them about their research. Thus, this model provides valuable and relevant professional development to graduate students in independence and communication skills.

Talented graduate students who are invested in good science communication stand out among their peers. As one participant stated, “I have a new appreciation for the challenges and opportunities associated with communicating science to laypeople. I have learned that the gulf is wide, but it is more of a gulf of jargon and ways of thinking, rather than intelligence or motivation.” By giving young scientists the tools to convey their research effectively, this program aims to bridge that gulf.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS


Table 1. Students’ mean ratings (out of 4) of their comfort with presenting science to nonscience audiences

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