



A Pilot Workshop for Developing Early Career Scientists' Communication Skills

Research Team

Hayley Schiebel, PhD

Assistant Professor, Center for Urban Ecology and Sustainability
Suffolk University
hschiebel@suffolk.edu

Echo Rivera, PhD

Owner, Creative Research Communications LLC
echorivera.com / stellarslides.com
admin@echorivera.com / @echoechoR

Rebecca Stone, PhD, MPH

Assistant Professor, Department of Sociology & Criminal Justice
Suffolk University
rebeccajstone.com
rstone@suffolk.edu / @stone_prof

Jessamyn Fairfield, PhD

Lecturer, School of Physics
National University of Ireland Galway
jessamynfairfield.com
jessamyn.fairfield@nuigalway.ie / @ultrajessamyn

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Conflict of Interest Statement

Dr. Jessamyn Fairfield and Dr. Echo Rivera were evaluated on the impact of their training sessions and were also part of the research team. However, they were not involved in the data entry or analysis. They informed the evaluation questions to ensure they were relevant and assessed content in the training. In addition, they helped write the report.

BACKGROUND

Scientists, academics, and researchers must have strong communication skills to share their work and maximize the impact of their research. Graduate schools, however, rarely include this type of training in their programs, which creates a significant skill gap for early career professionals. As a result, many professionals in academic and scientific careers struggle to communicate effectively to their peers, outside disciplines, and the public. Two of the most common types of communication used by scientists when sharing their research are verbal presentations (to both scientific audiences and more general audiences) and visual presentations (e.g. slide presentations, scientific posters). Although many scientists are trained to communicate with their disciplinary peers, few receive any training – formal or informal – to improve their communication across disciplines, with policy decision-makers, and with the public. This limits the transformative potential of science for informing social policy and practice.

Gaps in Verbal Communication Skills

Two hurdles have made the transition from traditional, top-down communication to more effective methods (i.e., two-way open dialogue) difficult for academic scholars. The first is the issue of motivation: why should an audience listen? Scientists and their peers may have an intrinsic interest in the work but reaching more diverse audiences requires a more narrative approach that uses storytelling techniques to make the research results more persuasive (Blanton and Ikizer, 2019). Verbal presentation skills are rarely learned by osmosis, and training to assist scientists in storytelling and use of appropriate language improves the impact of informal science communication (Petherick et al., 2017). Speaker training at public engagement events is necessary in order to induce real change in the audience's attitudes, emotions, and knowledge about science (Ocobock and Hawley, 2020). Crafting these persuasive narratives is a skill that must be developed, but this skill is not often taught on the path to a science degree. The result is that many scientists present their research in a way that does not influence or persuade the audience to engage in dialogue and be moved to action, meaning that their research is not reaching its maximum potential impact.

Gaps in Visual Communication Skills

Many science communication efforts involve visuals of some kind, like a slide presentation, a scientific poster, or an informative handout. Visuals can influence effective engagement with a message before it is cognitively processed (Jarreau et al., 2017). Audiences are capable of processing visual stimuli so rapidly that processing can occur at subconscious levels but still

influence cognitive engagement with science (Cass and Walker, 2009; Sleenhoff et al., 2015). Rodriguez Estrada and Davis (2015) argue that it is uncommon for scientists to be trained in visual literacy, and this leads to an over-reliance on written communication with poorly integrated visual elements. The authors also note that visual communication is key to audience-centered science communication and suggest that students be trained in finding and using visual materials, evaluating and critiquing the visual elements used in communication, using visual media effectively, and how to navigate the ethical, legal, social, and economic concerns when using visual media (Rodriguez Estrada and Davis, 2015). Another study of 80 medical students found that implementing effective design strategies into lectures was related to improved retention in the short- and long-term over lectures with mostly text-based slides (Issa, et al., 2013).

Unfortunately, most academics use visual aids ineffectively. Kosslyn et al. (2012) analyzed how well academics' slide presentations followed principles of human perception, memory, and comprehension. They found that (a) eight effective communication principles were frequently violated in academic presentations; (b) audience members are annoyed, frustrated, or distracted by these violations but unable to explain why; and (c) untrained observers struggle to identify effective versus ineffective presentation strategies. In other words, without adequate training, it is difficult to identify ineffective presentation elements and to reverse-engineer effective design. If scientists are to design effective slide-based presentations, training on these principles is essential.

Lack of Training and Professional Development

Without adequate training in communication, scientists tend to (unintentionally) reinforce ineffective communication strategies. Despite the momentum of a growing communication field and pressing need for the delivery of accurate and engaging scientific information to any audience, such training is not always available for early career scientists: undergraduate students, graduate students, and those within two years of graduation from a graduate degree program (Coil et al., 2010; Brownell et al., 2013; Mercer-Mapstone and Kuchel, 2015; Cirino et al., 2017). Mercer-Mapstone and Kuchel (2017) conducted a meta-analysis of 99 articles from the fields of science, science communication, and education and found that only 19 of these articles contained information relevant to communication with non-scientists (and, by proxy, other scientific disciplines as well). The Alan Alda Center for Communicating Science at Stony Brook University, the American Association for the Advancement of Science (AAAS), and the New York Academy of Science's Science and the City program offer programs for masters and PhD students in scientific disciplines to explain fundamental scientific concepts to the general public (Brownell et al., 2013). Communicating Science (ComSciCon) is an annual communication workshop founded in Cambridge, Massachusetts in 2013 by graduate students that provides free science communication training for graduate students accepted into the program.

Similarly, ScienceTalk is an annual workshop held in Portland, Oregon since 2017 that is for a scientist at any level to learn how to communicate their work to non-scientists or those outside of their discipline. Lastly, the National Academy of Sciences Arthur M. Sackler Colloquia on the Science of Science Communication began in 2012 with a similar mission statement to that of ScienceTalk. These programs are not intended to train future science journalists, but to provide communication skills to research scientists so that they may better convey the details and impact of their work to any audience. However, these programs attract a self-selecting group of scientists who are already aware of the importance of communication training and seek out these additional opportunities. For those who “don’t know what they don’t know,” training opportunities are slim.

Current Project

The goal of this pilot was to test whether we could train early career scientists on the knowledge and skills to improve their communication skills through an intensive workshop focused on verbal and visual communication. To meet this objective, a full day workshop funded by the National Science Foundation was held at the 2019 annual meeting held by the Association for the Sciences of Limnology and Oceanography (ASLO) and the 2020 Ocean Sciences Meeting (OSM) co-sponsored by co-sponsored by the ASLO, the American Geophysical Union (AGU), and The Oceanography Society (TOS).

THE COMMUNICATION SKILLS WORKSHOP: A PILOT

Locations

We piloted a one-day workshop package of both verbal and visual communication skills. The goal was to create a one-day workshop that could be implemented at any research conference, so scientists already attending a conference could benefit from a communication skills workshop. We piloted this workshop twice: (1) The ASLO conference in San Juan, Puerto Rico in February 2019, and (2) the OSM conference in San Diego, California in February 2020.

ASLO (sole sponsor of the 2019 meeting and co-sponsor of the 2020 meeting) brings together a diverse, international scientific community that creates, integrates, and communicates knowledge across the full spectrum of aquatic sciences. ASLO also aims to advance public awareness and education about aquatic sciences and research while promoting scientific stewardship of aquatic resource.

Workshop attendees participated voluntarily in a full day workshop comprised of verbal and visual communication skill sessions. The workshop was advertised with preregistration and was free for attendees, with 50 available slots. The only requirement was that participants attend the entire day.

Training Content

Verbal Communication Skills

The all-day workshop included two verbal face-to-face communication sessions, facilitated by Dr. Jessamyn Fairfield. These sessions were based in performing arts methods that use improvisation to help researchers develop clear and engaging stories about their work with good vocal technique and physical awareness. This training has been validated in the Bright Club Ireland model of science communication over five years of evaluation and testing (Roche et al., 2020). The training involves improvised monologues and research pitches, without pre-prepared text, with special emphasis given to three act story structure, accessibility of language, and body language. Improvisation exercises, which have been effective at teaching

science communication in a university context (Ponzio et al., 2018; Rossing and Hoffman-Longtin, 2016), were also employed. The provision of several opportunities to practice to a live audience, as well as interactive feedback, helped address anxiety about public speaking in the group by repeated exposure in a safe and supportive environment. The use of humor was also discussed, as humor can be an important tool to frame science in new ways and improve the perceived accessibility of technical topics (Pinto et al., 2015; Riesch 2015). Thus, the verbal communication sessions provided a highly interactive, hands-on opportunity for participants to develop their skills in storytelling and communication of their research.

The second pilot (2020) incorporated feedback from the first pilot (2019). In 2019, feedback around the informal verbal presentation session was very positive, but while the content covered in a science writing session was considered valuable, the late timing of the session in the overall workshop schedule meant that participants were running low on energy. The time blocks given to writing prompts in this section seemed more useful in terms of recovery than activity. In response to feedback from the 2019 workshop, in 2020 the writing prompts around research past, present, and future were repurposed to create a second informal practice session, which worked better to keep up participant energy. After these sessions participants were encouraged to write down some of the informal research pitch they had developed through the exercises to have some “takeaway” text for future use (which in the 2019 workshop was generated by the writing prompts). The goal of this change was to maintain participant energy and engagement while still providing opportunities to develop both spoken and written material about their research interests and goals.

Visual Communication Skills

Three visual communication sessions were delivered via webinar by Dr. Echo Rivera. Workshop participants learned how to design and deliver presentations that help their audience pay attention, understand the material, remember the material, and use the information at a later time. More specifically, Dr. Rivera taught participants how to (a) keep their audience engaged and interested; (b) remove clutter and distractions from their slides; (c) use less text and more visuals; (d) use design to enhance audience learning; and (e) design compelling and easy-to-understand data visualizations. The content of this webinar was developed by Dr. Rivera, who has a mixed method research/evaluation background in the social sciences, and combines lessons from psychology, pedagogy, graphic design, and information design. The content for these sessions was developed over years of testing with multiple audiences (scientists, academics, evaluators, and service providers). This training is software neutral and teaches principles that can be applied regardless of which slide application participants use. As such, the session format did not require participants to have a laptop with them to learn the material.

Dr. Rivera joined the team to pilot how much material is practical and effective to squeeze into four hours, in one day. In her regular training module, Dr. Rivera conducts hybrid “flipped” style trainings (where participants watch 7 hours of training material through short, self-paced online videos and then join live sessions with Dr. Rivera to ask questions, practice material, or see custom slide makeovers). Or, for live sessions, she breaks 4.5 hours of material into three separate 90-minute webinars. Dr. Rivera generally avoids doing half- or full-day workshops due to cognitive overload and exhaustion concerns. Finally, Dr. Rivera also wanted to test whether this material can effectively be delivered via broadcast to a large room, instead of a traditional webinar (where participants join via their own device).

The second pilot (2020) incorporated feedback from the first pilot (2019). In 2019, the feedback was positive and we noticed significant change in participants’ scores from before and after the workshop. However, some participants noted that the fast-paced nature of the webinar made it difficult to follow along for people whose first language was not English. In 2020, Dr. Rivera activated PowerPoint’s live subtitles feature to improve the accessibility of the training. Additional questions regarding subtitles were included in the evaluation survey. In 2019, some participants also noted that, while they were exhausted by the end of the conference, they also wanted to learn more information—particularly about data visualization and how to visualize aquatic sciences data, specifically. In 2020, some new material was added (while other material was left out), with more before/after makeovers for data visualizations. Finally, in 2020 Dr. Rivera incorporated some Poll Everywhere interactive sections.

Evaluation Surveys

Dr. Rebecca Stone managed all aspects of the evaluation protocol, data entry, and data analysis. Dr. Stone worked with Dr. Fairfield and Dr. Rivera to develop relevant questions to assess the training material; however, neither was involved in any part of the data entry or analysis.

All study protocol and supplemental materials were approved by the Suffolk University Institutional Review Board (IRB) prior to implementation at the workshops. Evaluation folders containing a welcome letter, workshop agenda, informed consent document, five evaluation forms, and three packets of handouts for the visual communication sessions were prepared for each participant. The welcome letter provided information and links for electronic participation in the webinar sessions of the workshop, as well as links to retrieve handouts and other information after the workshop ended. Upon arrival, each participant signed in and received an evaluation folder along with an explanation of the contents and the consent process. Signed consent forms were collected at the beginning of the workshop. It was important to avoid any connection between the completed evaluation forms and participants’ identifying information, as well as have a way to link the same participant to all the forms in their evaluation packet. To

resolve this issue, the evaluation forms in each folder were numbered with the same identifier. For example, the first participant received a folder in which all evaluation forms were marked with a “1” in the top right corner. There was no master record of names linked to folder numbers, so responses were completely confidential.

There were five evaluation forms in total in each evaluation packet. Each form was printed on a different color of paper to allow for easy identification both by participants and by the workshop organizers, who could quickly scan the room to make sure everyone was filling out the right form at the right time. The first evaluation form was the pre-workshop evaluation, which covered simple demographics and all pre-workshop measures. The next three evaluation forms were short, one-page post-session questionnaires designed to assess retention of material from each visual communication session. Finally, the post-workshop evaluation form repeated many questions from the pre-workshop evaluation, as well as assessments of the workshop overall and opportunities to provide constructive open-response feedback. Evaluation forms were collected by the authors throughout the workshop.

Responses were entered into SPSS for data collation and analysis. Responses to open-ended questions were exported into an Excel document for thematic coding. Paired-samples t-tests were used to compare change from pre-workshop to post-workshop responses to Likert items (de Winter & Dodou, 2010).

Due to the changes in content, particularly with Dr. Rivera’s visual communication sessions, some major changes were made to the questions asked and question structure for the 2020 pilot. These are noted when relevant.

Attendee Demographics

In 2019, all 50 registration slots were filled, but there were several no-shows from this list on the day of the event. Our team suspects that this is because there was no fee or requirement to attend once registered. Luckily, however, several people were walk-ins and we ultimately had 41 participants attend the first pilot. All 41 participants completed the evaluation surveys.

In 2020, all 50 registration slots were once again filled. This time, however, Dr. Hayley Schiebel sent several reminder emails to the registrants before the event. For the second pilot, all 50 registrants attended the workshop and 40 participants completed the evaluation surveys.

In 2019, workshop participants ranged in age from 20 to 52 years, with a median age of 25 years. The age range was similar in 2020 (21-53 years old), but the median age was higher at 28.5 years. This slight increase in mean age is reflected in the distribution of career status among participants. In 2019, participants were overwhelmingly either undergraduate or

doctoral students, with very few post-doctoral or more advanced faculty and industry researchers. In 2020, only 3 participants were undergraduates, and the balance shifted toward master's, doctoral, and post-doctoral students, as well as industry researchers.

For both pilot workshops, most participants were women (71% women in 2019; 77.5% women in 2020). All other participants indicated they were men (29% in 2019; 22.5% in 2020). Other gender options were provided, but these responses were not selected by any participants.

Most participants in the first pilot were students, whereas nearly half of participants in the second pilot were early or mid- career scientists.

Table 1. Participant demographics

	2019		2020	
	n	%	n	%
Undergraduate student	11	27	3	7.5
Master's student	6	15	12	30
Doctoral Student	16	39	6	15
Post-doctoral researcher	3	7	6	15
Non-tenure track faculty	1	2	0	0
Tenure-track faculty	0	0	1	2.5
Researcher in industry	1	2	6	15
Not listed above	3	7	6	15

VERBAL COMMUNICATION SKILLS

As described above, the verbal communication skills training incorporated improvised monologues and research pitches, with an emphasis on story structure, accessible language, and body language. These activities were designed to increase participants' comfort in improvising and delivering brief explanations of their research interests or study outcomes that would be more engaging and persuasive for a general audience. Based on these training goals, our evaluation of these sessions focused on participants' pre- and post-workshop comfort with public speaking and their knowledge of storytelling narrative structures. Participants were asked to report on their **level of comfort** speaking to a variety of audiences before and after the workshop. In addition, participants were asked three questions about whether they can **describe their research quickly** and **avoid using jargon**. Finally, participants were asked if they understood the **importance of storytelling** in science communication. All questions were presented on a Likert-type scale from 1 (strongly disagree) to 4 (strongly agree) and remained the same from 2019 to 2020.

In both 2019 and 2020, participants increased their agreement with all questions. These pilot results indicate this workshop was successful at improving the verbal communication skills of workshop attendees. All increases were statistically significant.

Surprisingly, some items saw a smaller mean change from 2019 to 2020. For example, the mean change for "I could adequately describe my research interests in 30 seconds" was .63 in 2019 but went down to .39 in 2020 – still positive and in the desired direction, but a smaller shift. However, this is likely because the pre-workshop mean for this question was slightly higher in 2020 compared to 2019. In fact, for all items, the 2020 pre-workshop means were higher than 2019 pre-workshop means, suggesting that 2020 participants came into the workshop with greater confidence in their public speaking skills.

Participants
reported
increased
comfort
speaking "off
the cuff" about
their research.

The mean change for the vast majority of items remained similar or improved between 2019 and 2020. For example, the mean change for **“I can speak comfortably to a non-scientist audience about science”** was .18 in 2019 and .29 in 2020. This is a promising finding, given that pre-workshop confidence in this item was already higher in 2020 and, yet still showed a higher mean change. Another example is the item “I can avoid using too much technical jargon when speaking about my scientific interests.” The mean change for this item was .36 in 2019 and .47 in 2020 — even though the pre-workshop mean was higher in 2020.

Table 2. Significant pre-workshop to post-workshop change in agreement where all variables were measured on a scale from 1 “Strongly Disagree” to 4 “Strongly Agree”

	2019		2020	
	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)
I can speak comfortably to a general audience.	2.67 (.87)	2.89 (.72)	2.97 (.88)	3.21 (.74)
I can speak comfortably to a non-scientist audience about science.	2.92 (.81)	3.10 (.64)	3.13 (.74)	3.42 (.60)
I can speak comfortably to an audience of scientists about science.	2.36 (.87)	2.85 (.81)	2.79 (.81)	3.29 (.61)
I can speak comfortably “off the cuff” (with little preparation) about science.	2.62 (.91)	3.10 (.75)	2.81 (.78)	3.31 (.58)
I could adequately describe my research interests in 30 seconds.	2.68 (.84)	3.32 (.66)	2.87 (.62)	3.26 (.64)
I can avoid using too much technical jargon when speaking about my research interests.	2.85 (.74)	3.21 (.52)	3.03 (.68)	3.50 (.65)
I understand the importance of storytelling in science communication.	3.31 (.69)	3.72 (.46)	3.58 (.60)	3.87 (.34)

* indicates a statistically significant mean increase from pre- to post-workshop.

VISUAL COMMUNICATION SKILLS

The visual communication skills workshop was longer than and had different goals than the verbal communication workshop. This workshop focused exclusively on presenting information using presentation slides (e.g., PowerPoint, Keynote, Google Slides). There are a significant number of myths that pervade this topic (e.g., “You should use as few slides as possible”) as well as cultural barriers to change (e.g., concerns that well-designed slides aren’t “professional” enough). Plus, because PowerPoint is a relatively easy application to use and because no formal training is provided, scientists can often feel as though they are already doing most things correctly, and only need a few quick “tips and tricks and hacks” to improve their slides. This, however, is incorrect.

As such, much of the training content is about combatting these myths, helping participants unlearn their bad habits (which start at how they even approach presentations), and provide new knowledge and attitude change relating to presentations. When preparing the evaluation survey, the research team **expected that participants’ confidence in their presentation skills will decrease after the workshop sessions** because they would be “unlearning” many of the popular presentation myths they may have believed. It was going to be important to assess participants’ change in multiple ways, beyond skills confidence. Therefore, the evaluation survey questions for this topic include questions about knowledge, attitudes, confidence, and preparedness. In addition, true/false and Likert-type questions were asked.

Items were reverse coded when needed so that a high score reflects the desired answer.

Assessing Change in Presentation Design Knowledge & Attitude Across Two Pilot Groups

These evaluation questions received significant revisions between 2019 and 2020. Overall, the results indicate that this workshop improved participants' knowledge and attitudes related to effective presentation design in a scientific setting.

Evaluation questions were revised after the 2019 pilot.

Upon review of the 2019 data, the research team realized that several improvements to the evaluation survey questions were needed. We realized that participants may be reporting the correct answer without actually agreeing with it. Several of the true/false questions were converted to Likert-type scales (strongly disagree to strongly agree) to better assess whether participants agreed with the suggestions provided in the training. In addition, several questions were reworded or removed to improve clarity. We

have done our best to summarize the findings across both years, given these changes. Reflections on these evaluation survey questions are provided in a later section.

It is also important to note in advance that the 2020 participants came into the workshop with higher levels of knowledge compared to the 2019 group, which may explain some of the differences in findings between the two pilot sessions.

True or False? Change in Knowledge of Small and Specific Slide Design Strategies

In 2019, participants were provided a list of statements about effective presentations and were asked whether it was true or false. As expected, most participants believed in myths related to effective presenting. Most participants chose the “incorrect” answers prior to the workshop. They also demonstrated a large increase in “correct” answers after the workshop, and all improvements were statistically significant. The biggest improvement occurred with the statement **“bullet points do more harm than good in a presentation.”** The answer is true, but only 7% of participants chose the correct answer at pre. By the end of the workshop, 100% of participants chose the correct answer. This question was converted to a Likert-type scale in 2020, where we noticed another statistically significant increase in the “incorrect” responses (disagree/false) to “correct” responses (agree/true). Specifically, at pre the mean response was 1.93 (.66), which increased to 3.53 (.72) post-workshop. This is a mean increase of 1.6, which was significant ($p=.000$).

In addition to the true/false items, participants were asked to identify “Which of the following is the most harmful thing you can do in your presentations?” This item had four possible responses: being shy, saying “um” too much, adding clutter to the slides, or using a lot of slides. The correct response explained in the workshop materials is “adding clutter to the slides.” In

2019, 48% of participants answered this correctly and 55% of participants answered this correctly. After the workshop, 98% of participants answered this correctly (2019) and 90% answered this correctly in 2020. For both years, the positive change was statistically significant. All other questions were either deleted or converted to a Likert-type scale for 2020.

Table 3. Participants' pre- and post-workshop responses to visual communication questions

	Pre % correct	Post % correct	Change	p-value
Bullet points do more harm than good. (T)	7%	100%	+93%	.000
Which is the most harmful thing you can do in your presentations? (Clutter)	48%	98%	+50%	.000
Graph titles should be descriptive only. (F)	45%	93%	+48%	.000
Information design principles can be broken if you need to fit more text on your slides. (F)	80%	95%	+15%	.010
Your presentation slides should be able to stand alone without you talking. (F)	46%	73%	+27%	.003

In 2019, the statement with the lowest percentage of correct answers after the workshop was the statement **“Your presentation slides should be able to stand alone without you talking.”** This statement is false. Only 46% of participants chose the correct answer at pre, and this percentage increased to 73% at post. Upon reflection, the research team suspected that the wording of the question was confusing or unclear. The question is intended to assess the change in knowledge about how to choose visuals in an effective way. Specifically, many academics spend too much time trying to find a perfectly literal visual. The training shows participants how to find images that are somewhat vaguer so they can be used in multiple ways. This question was revised in 2020 to say, **“The images or visuals on your slide should be self-explanatory without text or speech”** and the goal was to see more people *disagree* with this statement. That is exactly what happened as more people disagreed with this statement after the 2020 workshop (M=2.22, SD=.91) than before the workshop (M=3.00, SD=1.12). This difference was statistically significant.

In 2019, participants were asked whether “**information design principles can be broken if you need to fit more text on your slides.**” The correct answer is no, they cannot (false). Most participants knew this before the workshop (80% chose the correct answer), and this increased to 95% at the end. This question was converted to a Likert-type scale in 2020 and, similarly, most participants knew the correct answer before the workshop ($M=3.49$, $SD=.76$). There was little room for improvement, which likely explains why the increase after the workshop was not statistically significant ($M=3.62$, $SD=.67$).

Agree or Disagree? Change in Knowledge and Attitude About Effective Presentation Design More Broadly

The remaining questions were Likert-type scales in both 2019 and 2020, which allows for more comparisons between the workshops. As a reminder, the content for each year changed. In 2020, there was less information about how to find vague visuals (compared to literal ones) and more data visualization makeovers. Generally speaking, the questions in this section assess knowledge and attitudes about effective presentation design more broadly (e.g., questions that impact the entire presentation as a whole, rather than what to do on a specific slide).

Perhaps the most promising finding was improvement in the agreement level on the role of emotions in science communication for both 2019 and 2020. Participants were asked to agree or disagree with the statement “**emotions should be avoided in science communication.**” The goal was to see strong disagreement with this statement, as emotions are a key factor in resonating with any audience. Promisingly, there was an increase in disagreement that was statistically significant for both 2020 (as a reminder, this item was reverse coded, so that a higher score actually indicates more disagreement—the desired outcome).

Another promising finding was the increase in agreement with the statement, “**it is the presenter’s responsibility to do as much as they can to help the audience pay attention.**” A common attitude that contributes to ineffective presentations is the idea that it is the responsibility of the audience to pay attention and that the burden rests on them. Although participants were already in relatively high agreement with this statement at the pre-workshop, the increase in agreement was still significant at post, for both 2019 and 2020.

Table 4. Participants' pre- and post-workshop responses with respect to effective presentation skills

	2019		2020	
	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)
Emotions should be avoided in science communication. (reverse coded)	2.93 (.79)	3.29* (1.01)	3.39 (.59)	3.79* (.53)
It is the presenter's responsibility to do as much as they can to help the audience pay attention.	3.46 (.64)	3.83* (.38)	3.35 (.58)	3.93* (.27)

* indicates a statistically significant mean increase from pre- to post-workshop.

Interestingly, the item **“you should add headlines to slides when presenting data”** did show a statistically significant change in 2019, but not 2020. Notice, however, that the 2019 post mean was 3.59, which was the pre-workshop mean in 2020. This indicates that there was already high agreement on this item in 2020, compared to 2019, which may be why there was no statically significant change with that group.

Table 5. Participants' pre- and post-workshop responses regarding headlines in slide design

	2019		2020	
	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)
You should add headlines to slides when presenting data	3.17 (.63)	3.59 (.63)*	3.59 (.50)	3.59 (.64)

* indicates a statistically significant mean increase from pre- to post-workshop.

There was no significant change in participants' responses about animations or including more information on the slides you have time for—neither in 2019 nor 2020. In 2019, the question was worded “you should avoid using animations or animated slide transitions” and the goal was to have participants disagree with this statement, but participants did not significantly change their response after the workshop. The research team thought this may be due to participants' thinking of nuanced situations, so we strengthened the language of this item for 2020 to “you

should always avoid using animations or animated slide transitions.” The goal, again, was to have more participants disagree with this after the workshop, but there was still no significant change in responses. Similarly, there was no significant improvement to the item “you should include all your data on the slide if you won’t talk about it.” The goal was to have participants disagreement with this statement, however there was no significant change in response in either 2019 or 2020. It is worth noting that for the item “You should include all your data on the slide even if you won’t talk about it,” pre-workshop means were already quite high in both 2019 and 2020, suggesting that workshop attendees already know not to include unnecessary data in their presentations. It is not surprising that the mean change for this item was not statistically significant. For the item “You should avoid using animations or animated slide transitions,” it may be that when participants think of “animations” in PowerPoint presentations, they think of distracting clip art animations instead of the helpful slide transitions or animated diagrams suggested by Dr. Rivera’s training. This is also an area that receives only brief mention in the one-day workshop.

When Dr. Rivera conducts more comprehensive training sessions, these areas are covered in more detail and with examples. This is a limitation of providing shorter training sessions. The one-day workshop does not provide enough time to fully cover even the basic material for effective presentation skills, let alone the opportunity to apply the skills in hands-on examples.

Table 6. Items with no statistically significant change in presentation design knowledge from the pre- to post-workshop in 2019 and 2020.

	2019		2020	
	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)
You should avoid using animations or animated slide transitions. (reverse coded)	2.37 (.99)	2.15 (.94)	2.89 (.71)	3.03 (.91)
You should include all your data on the slide even if you won’t talk about it. (reverse coded)	3.59 (.74)	3.77 (.63)	3.79 (.57)	3.90 (.31)

Change in Presentation Skills Confidence

Participants were asked to rate their confidence in several presentation domains on a scale of 1 (Not at all confident) to 4 (Very confident). As expected, participants reported a decrease in confidence for most items. In both 2019 and 2020, almost all pre-workshop means in this category were higher than post-workshop survey means. For example, before the training, mean confidence that **“My slide presentations are well designed”** was 2.6 in 2019 and 2.71 in

2020, but dropped to 1.9 and 2.2, respectively. That is a mean change of -.68 and -.50, respectively. As another example, before the training mean confidence that **“I have the appropriate amount of text on my slides”** was 2.6 in 2019 and 2.89 in 2020, but dropped to 1.9 and 2.26, respectively. That is a mean change of -.66 and -.63, respectively.

The only item to break this pattern was **“I can present my data in a way that is not overwhelming for my audience.”** In 2019, this was the only item to show an increase in confidence. This is likely because data visualization is a hot topic in the presentation design world, and many prioritize learning this skill above the other skills taught in this training (e.g., text design, custom illustrations, cognitive overload). Thus, it’s likely that this is the one area in which participants knew the most about before the workshop. Interestingly, however, in 2020 there was no significant difference between the pre and post. This may be because the pre-workshop mean was slightly higher. It could also be because the most significant changes to the content between the first and second pilot were in the data visualization section. Future content development and testing is needed to parse out what happened here.

Table 7: Pre-workshop to post-workshop change in confidence on a scale from 1 “Not at all confident” to 4 “Very confident”

	2019		2020	
	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)
My slide presentations are well designed.	2.61 (.67)	1.93 (.65)*	2.71 (.57)	2.21 (.91)*
I have the appropriate amount of text on my slides.	2.59 (.71)	1.93 (.88)*	2.89 (.61)	2.26 (.98)*
I use graphics and visuals effectively.	2.66 (.69)	2.32 (.88)*	2.68 (.81)	2.21 (.96)*
I can present my data in a way that is not overwhelming for my audience.	2.30 (.76)	2.90 (.67)*	2.50 (.69)	2.42 (.64)

* indicates a statistically significant change from pre- to post-workshop.

Post-workshop Self-assessment and Degree of Preparedness Moving Forward

The biggest challenge of facilitating a workshop on presentation design is that participants begin the workshop with varying degrees of knowledge about presentation design. For the post-workshop evaluation surveys, we wanted to provide participants with a change to report on how well they are already doing on the various domains covered by the workshop. Therefore, a series of questions that asked participants to rate their current slides, based on the information they just heard, was created. These begin with the stem “**I currently...**”.

Also, given the anticipated challenges with assessing confidence, the research team decided to assess how prepared participants were to apply this new material moving forward. These begin with the stem “**After this workshop, I feel prepared to...**” The original intention was to exclude participants who reported that their slides were already well-designed from these questions. However, due to the small sample size, we are reporting the results for all participants – even those that felt their slides did not need improvement. For that reason, percentages for each response are provided, because showing means would hide these nuances.

In the evaluation survey, for each statement, participants were asked whether they strongly disagree, disagree, agree, or strongly agree. Responses have been condensed into disagree and agree in the table provided below.

Across several domains, the degree to which participants felt their current presentations had the specified problem (e.g., too much text) varied. The vast majority of participants in both 2019 and 2020 felt their had too much clutter on their slides (90.2% and 87.5% respectively). After the workshop, however, both groups felt confident they could identify the clutter on their slides. **For all domains presented after the workshop at least 90% of participants felt prepared to take action and improve their slides.** This indicates that not only did the visual communication workshop improve participants’ knowledge and attitude about presentations in several ways, but also prepared participants to improve their future presentations.

Table 8. Participant agreement regarding preparedness moving forward with visual design

	2019		2020	
	% disagree	% agree	% disagree	% agree
Clutter				
I <i>currently</i> have clutter on my slides that I need to remove.	9.8	90.2	12.5	87.5
<i>After</i> this workshop, I feel prepared to identify the clutter on my slides.	9.8	90.2	0	100
Text				
I <i>currently</i> have too much text on my slides.	24.4	75.6	23	77
<i>After</i> this workshop, I feel prepared to reduce the amount of text on my slides.	0	100	2.6	97.4
<i>After</i> this workshop, I feel prepared to design the text on my slides more effectively.	2.4	97.5	0	100
Visuals				
I <i>currently</i> don't use the right type of visuals or use them effectively.	31.7	68.3	30.8	69.2
<i>After</i> this session, I feel prepared to choose or use visuals more effectively than before.	0	100	5.2	94.9
Data				
I <i>currently</i> present my data in overwhelming or confusing ways.	42.5	57.5	33.3	66.6
<i>After</i> this session, I feel prepared to present my data in less overwhelming or confusing ways.	0	100	5.1	94.9

OVERALL WORKSHOP EVALUATION

The goal of this pilot was not only to test the verbal and visual communication training content, but also to determine whether an intensive one-day preconference workshop could work well. In addition to the content-specific questions described above, the post-workshop evaluation asked respondents to share their feelings about the workshop overall. We asked participants if they would recommend the workshop to others, if the workshop content was useful, and what specifically they liked or disliked about the workshop content and format.

Quantitative Survey Results

The quantitative survey portion of the post-workshop evaluation measured whether participants would recommend the workshop to others and if the workshop content would be useful in their careers. Participants overwhelmingly felt that the workshop was helpful and would recommend this workshop to colleagues.

Table 9. Participant feedback regarding effectiveness of the workshop overall

	2019		2020	
	% disagree	% agree	% disagree	% agree
I would recommend a workshop like this to my colleagues, mentees and/or students.	7.3	92.7	7.2	92.8
I would recommend that other scientific conferences offer workshops like this.	4.9	95.1	0	100
This workshop material will be useful for advancing my career or professional goals.	10	90	0	100
This workshop provided me with new information and skills to improve my science communication.	12.2	87.8	0	100

Participants in both years felt that this workshop should be held at other scientific conferences as well. This was one of the goals of creating a portable workshop package that could be tailored slightly depending on the conference materials. Because the conference participants here were all oceanographers or limnologists, it would be ideal to bring in a specialist from these or similar disciplines to tailor the workshop materials to more closely fit participant needs, for example, by showing discipline-appropriate slide design or data visualization examples. Participants also felt that the material would be useful in advancing their career or professional goals, and that the workshop provided them with new information and skills to improve their science communication. To better understand which groups found the workshop particularly useful, we ran a series of analyses to compare mean responses on these items across genders and career stages. There were no significant relationships between career status and likelihood of recommending the workshop or perception of its usefulness. Similarly, there were no significant relationships between gender and these variables. In short, the deliverables in this workshop are useful for all genders and career stages, which was another ultimate goal of the package workshop.

Open-ended Responses

2019 and 2020 workshop participants had the opportunity to offer more feedback in response to several open-ended questions related to the visual and verbal components of the workshop, each of provided interesting and different feedback.

“This will help me to not overwhelm my audiences in the future.”

For the open-ended questions specifically related to the visual communication portions of the workshop, it was clear that the participants (a) had not had a lot of training in visual science communication skills and/or had been trained improperly and (b) learned a great deal about how to move forward with visuals in their science mostly for peers and the scientific community. When asked what most surprised them in the session materials, most participants gave examples of specific presentation design advice from the workshop. Most comments were about their surprise that bullet points are unnecessary clutter on a slide, the importance of decluttering slides, and advice about font size. The second most popular category of responses to this prompt could be described as “mythbusting.” For example, some participants had been taught strict rules about how many slides to use per minute of their presentation and were surprised to learn how to use more slides to create a more engaging audience experience. Many participants reported being surprised by how easily they were able to communicate their work in 15 seconds or how comfortable they were talking to new people about their work in an informal setting. When asked about which information or activity from the workshop would be the most useful for them in the next year, most participants specifically

mentioned the information about slide design and how beneficial these tools would be in their research and course presentations. Responses mentioned applying the workshop lessons to senior thesis presentations, posters, yearly talks in academic departments, dissertation defenses, and conference presentations.

Comparatively, responses specifically related to the verbal communication portions of the workshop seemed to find that it would be most helpful for relaying science to a non-science audience. Participants also found the 2019 verbal storytelling session helpful and mentioned that they will use this approach in future presentations to fully break down their research to either a non-science audience and/or a scientific community other than their own. Many participants mentioned that the improvisation exercises and hands-on activities in small groups were a great way to practice these skills versus learning them from a lecture. For example, participants were given the opportunity to break down the core of their research into smaller and smaller breaks of time with partners. Participants could use this skill specifically at a research conference in a poster hall when they need to get the attention of a passerby (who may or may not have research interests similar to that of the presenter) in a small amount of time. This same activity would also be useful in trying to explain one's research to someone with no science background, like members of the general public who may need to be persuaded that scientific research matters, that research funding is a social good, and that research should inform public programs and policies. Whereas traditional scientific communication focuses on a one-way deficit approach whereby scientific speakers transferred facts to an audience (van der Sanden and Meijman, 2008; Mercer-Mapstone and Kuchel, 2015), this workshop aimed to support efforts to engage with the public in a more bidirectional dialogue (Cicerone, 2006; Scheufele, 2014), which can also be applied to cross-discipline communication.

**“It helped me
home in on the
core of what’s
important in
my research.”**

RECOMMENDATIONS FOR MOVING FORWARD

Based on the evaluation results, as well as the research team's reflections, we have compiled a list of recommendations and next steps for this workshop as well as for science communication training more broadly. Overall, the research team has demonstrated that a full-day conference workshop on communication skills is feasible and can have an immediate, positive impact on participants.

Overall, feedback from participants was positive. Most felt that this workshop was unique in offering helpful skills at the end of the workshop versus a simple example of a finished product to try to “reverse engineer” on one's own. Further, it was evident from pre- and post-data that participants did not have access to learning these types of skills in their academic training and a workshop of this kind fills that gap. More specifically, the visual and verbal communication skill sections of the workshop homed in on different tools that students were able to differentiate. The visual components of the workshop provided many ways to make scientific visuals more engaging for *any* audience, but participants felt that these skills would specifically help them present their data to scientific audiences. The verbal training components of the workshop, again, are applicable to any audience, but participants felt that these skills are most translatable when explaining their science to a public audience and/or scientists outside of their own field of expertise. In tandem, the combination of visual and verbal communication skills presented in these workshops is (a) unique, (b) missing from most existing scientific training, and (c) useful for presenting data to a wide range of audiences.

**A full-day
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Content

Not surprisingly, participants provided a conflicting set of feedback: they both wanted more information and found the workshops engaging, while also mentioning that there was too much information and it was an exhausting day. For example, one participant suggested cutting

one session *but noted they could not decide which one since all were so helpful*. In fact, several requests were made for adding *more* information to the workshop. For example, many participants wanted more information, clarification, and/or discipline-specific examples for how the base training on data visualization could be expanded to more advanced analyses.

Participants also mentioned an interest in training on other types of communication skills beyond the scope of the pilot. For example, many participants requested more practice with designing a poster for a scientific workshop.

This is a difficult challenge to address, but there are two possible paths forward. One option is to increase the depth of training and focusing on only one type of communication. As mentioned earlier, for example, Dr. Rivera's base presentation design training that covers the basics is actually 7 hours, not 4 hours long. Dr. Fairfield typically teaches two-hour training sessions that include reading and video material provided in advance, and the training audience typically has an upcoming presentation event for which they are motivated to prepare. Though the two-hour session is similar to the format offered in our 2019 and 2020 workshops, the pre- and post-training periods offer more opportunity for learning and practicing the material.

The other option is to increase the breadth of training and conduct shorter sessions on more topics. This is the option Dr. Schiebel will be moving forward with in the future, in collaboration with a new team of presenters with additional expertise in areas including scientific poster design, animations, and public speaking techniques. For future workshops, there will be one session on verbal communication skills, one session on presentations, and one session on poster design. To address the issue of information overload for participants, the workshop hosts aim to create a packet with online information and more resources for participants to use after the workshop concludes.

Webinar Delivery

In 2019 and 2020, Zoom Meetings was used to deliver the webinar portion of the workshop (the visual presentation training). Pre- and post-workshop surveys indicate that participants were still able to learn the information even though the workshop was not delivered in-person. In both 2019 and 2020, it was difficult to engage with participants, because as many of them did not have a laptop they could use for the chat feature. While a few attendees did use their laptop or phone to answer the questions and engage during the webinars, engagement was very low. For 2020, Dr. Rivera attempted to use Poll Everywhere to improve audience engagement, but this was still limited to official polls. In regular webinars, where every attendee joins with their own device (usually at their desk or at home), participants can use the chat or Q&A feature to engage at any time.

The research team was concerned about audio quality, video quality, and internet connection stability for both pilot sessions. In 2019, there were no technical issues and the webinar sessions went smoothly. In 2020, however, there were some audio issues with Zoom Meetings (likely due to how Zoom processes and compresses audio). It is unclear whether this would have been an issue with other software. Although this caused a small delay at the start of the workshop, the issues resolved over time. As with any training that involves using additional elements of technology, there is additional risk involved with doing webinar trainings at a conference setting.

After the pilot, the research team recommends that training be either fully in-person or a full, traditional webinar where every participant has a device that makes it easy to engage at any time. The middle ground approach implemented in the pilot significantly stifles engagement between presenter and audience.

Accessibility

Another challenge was that although many participants expressed a desire for more information, some participants provided responses that there was perhaps too much information covered or was too fast paced. For example, some participants mentioned a need for greater inclusion and accessibility for participants for whom English is a second (or third, etc.) language, some of whom found the workshop hard to follow due to pace. This may be a common challenge across all presentations as two participants requested more information about improving this aspect of their own presentations. In the 2020 workshop, this issue was addressed by adding captions to the visual presentation skills sessions. The captions were deemed accurate and non-distracting to most participants, though most did not find them helpful because they did not need this particular accommodation. The authors are not concerned that those who don't need the accommodation don't find the captions helpful and are more concerned that this accommodation is available to those who *do* need it. Therefore, the questions about **accuracy** and **distraction level** are probably the most helpful evaluation questions to ask.

Formal Training

It is an impossible feat to include all verbal and visual skills needed for early career scientists to communicate their research effectively in one day. Both presenters had more material to share than could comfortably be included in a day-long workshop, which points to an unmet need to have more comprehensive communication training embedded within graduate programs. Though some existing conferences and programs (e.g. The Alan Alda Center for Communicating Science at Stony Brook University, ComSciCon, etc.) do offer opportunities for science communication training, these opportunities cater to a self-selecting group of scientists who

must go out of their way to seek communication training and/or have geographical (and financial) access to the programs. Further, early career scientists may not be aware of such science communication training opportunities, may not appreciate the value of participating in them, or may already participate in such activities and not be rewarded for them, particularly in a culture where most professional development activities outside of the laboratory are discouraged (Bankston and McDowell, 2018). While this workshop was able to sharpen or even introduce new skills to participants, it is no way a substitute for something akin to a science communication course at either the undergraduate and/or graduate level.

Final Thoughts

The research team felt that this pilot workshop package was successful and well-received by participants in both years across multiple disciplines. This workshop clearly fills a void in science communication training for early career scientists who crave both visual and verbal skill development as they home in on their research specialties. The results of this workshop illustrated that each type of skillset (visual and verbal) provided tools for reaching different audiences. Generally, participants in both years felt that the visual communication skills would enable them to more clearly present their research to peers and those within their disciplines, perhaps at a scientific conference. Conversely, participants agreed that the skills focused upon the verbal sections of the workshop were beneficial particularly when communicating with in a more public forum where an audience member may be a non-scientist and/or one outside of the presenter's field of study.

In the coming year, the workshop will continue to evolve and specifically address lessons learned from two years of study such as accessibility issues and poster design (specifically requested from participants as a new content area to explore). Further research is needed in this continually changing field to overcome a few issues. First, a long-term follow-up with participants would be helpful to garner information about retention and things that worked/didn't work about workshop content and delivery. Testing the workshop outside of the oceanographic and freshwater sciences would better demonstrate the portability of the workshop package. Finally, because only one day is available at these types of research conferences, perhaps a test bundling the workshop as a curriculum to be taught more broadly could provide a stepping stone on the way to a more formal science communication course that should be developed as well.

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