Foundational Skills for Science Communication

A Preliminary Framework

Elyse L. Aurbach, PhD
Public Engagement Lead
Office of Academic Innovation, University of Michigan

Katherine E. Prater, PhD
Research Fellow
University of Washington

Emily T. Cloyd, MPS
Director for the Center for Public Engagement with Science and Technology
American Association for the Advancement of Science

Laura Lindenfeld, PhD
Executive Director for the Alan Alda Center for Communicating Science
Stony Brook University







Abstract

In order to work towards greater coherence across different training approaches supporting science communication and public engagement efforts, we present a preliminary framework that outlines foundational science communication skills. This framework categorizes different skills and their component parts and includes: identifying and aligning engagement goals; adapting to communication landscape and audience; messaging; language; narrative; design; nonverbal communication; writing style; and providing space for dialogue. Through this framework and associated practical, research, and evaluative literatures, we aim to support the training community to explore more concretely opportunities that bridge research and practice and to collectively discuss core competencies in science communication and public engagement.

Introduction

At a 2017 workshop on "Support Systems for Scientists' Public Engagement: Communication Training," and the 2018 Annual Meeting of the American Association for the Advancement of Science, John Besley and Anthony Dudo referred to the current training landscape supporting science communication and public engagement as the "Wild West." Having completed a series of interviews with North American organizations focused on training scientists to effectively communicate and engage, they observed that while there were similar themes as to content, there was a great deal of variation in the approach, specific content, and teaching philosophy that different organizations used to teach communication skills and motivate engagement. Similarly, they observed that members of the science communication and public engagement community were hungry to better connect to share insights and best practices (Besley & Dudo, 2017, 2018; Besley, Dudo, & Smith, 2017).

This insight - that there is a clear need for trainers, researchers, practitioners, and funders supporting science communication and public engagement to better connect and share knowledge - reflects several core challenges. Without this robust network and ability to share knowledge, different training organizations could provide conflicting or contradictory guidance, early practitioners could become unsure of which skills they need to be effective in public spaces (or how to gain those skills) and learning goals and/or training approaches could fail to build on the available evidence base.

In addition to the desire for different groups to share information and approaches, there is a clear need to develop shared definitions and a comprehensive organizational framework to guide science communication and public engagement for the field and its community of supporters. Defining concepts and creating coherence could provide guidance to different stakeholders and better support scientists interested in communication and public engagement. For the purposes of this work and in service of moving towards more inclusive definitions, we contextualize our use of "communication" and "engagement" with the following definitions. *Communication* is a process of developing shared meaning "that forms our experiences of and relationships with each other and the material world in which we live" (Craig, 1999). *Engagement* is multidirectional interaction among stakeholders that leads to different kinds of change, including (but not limited to) furthering relationships among stakeholders, building connections between seemingly unrelated viewpoints, promoting shared learning and understanding, discussing the benefits and risks of science and technology, and co-creating research and generating new scientific knowledge relevant to communities (adapted from the American Association for the Advancement of Science website, https://www.aaas.org/resources/communication-toolkit/what-public-engagement).

Beyond these definitions, we acknowledge the need to develop a coherent framework that tracks the early stages in which scientists may become motivated and equipped to communicate and engage effectively. Ideally, this framework would encompass all stages of a support system and/or trajectory, including building motivation, providing exposure to key ideas, building foundational communication skills, developing advanced skills and a coherent understanding of the norms and expectations for different areas of public engagement, and facilitating practice and experience for scientists in public engagement. The framework could

also allow organizations to both categorize their current support efforts and systematically explore areas for expansion.

Efforts to define aspects of such a framework are currently underway, including describing broad avenues for different types or pathways for public engagement (Storksdieck et al., 2016, Tropp, 2017, Lindenfeld et al., in prep), creating rubrics and approaches to evaluate aspects of scientists' communication and training (Baram-Tsabari & Lewenstein, 2013), and defining core learning goals for science communication training (Baram-Tsabari & Lewenstein, 2017).

This last effort is particularly important to the practice of developing curricula to teach science communication, and Baram-Tsabari & Lewenstein's learning goals differentiate content knowledge (Learning goal #2: "Comes to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science communication") and skills (Learning goal #3: "Uses science communication methods, including written, oral, and visual communication skills and tools, for fostering fruitful dialogues with diverse audiences"). Moreover, they begin to outline communication skills critical to enable effective public engagement. However, the list does not differentiate between skills and content knowledge which apply *regardless of context or audience* and which are most appropriate for *specific contexts or audiences*.

Over the past several years, we have worked to collect and categorize skills and content knowledge and begin to distinguish them into two distinct categories: foundational communication skills (practices and approaches that apply everywhere, regardless of communicator, context, or audience) and advanced, context-specific knowledge and skills (background, practices, and approaches which primarily apply in a particular public engagement context or sector). Here, our goal is to present our view of the key skills foundational to effective communication regardless of audience or context so the field can discuss and refine this framework.

Foundational communication skills and their component elements

Foundational communication skills can be separated into distinct categories. This categorization approach supports learning through objective-based training activities that enhance the exploration and development of these skills. Notably, many of the categories within this framework interact, which is one reason why they sometimes become conflated.

The categories of foundational communication skills include: identifying appropriate communication or engagement goals and objectives; adapting to a communication landscape and audience; messaging; narrative; language; visual design; nonverbal communication; writing style; and providing space for dialogue (listening/empathy/audience engagement) (Table 1, column 1). For the purposes of clarity, we offer some brief definitions to contextualize our current use of these terms. Identifying appropriate communication or engagement goals and objectives is the process by which stakeholders can define and articulate what the engagement effort is intended to achieve, facilitating a backwards-design process (Wiggins & McTighe, 2005). The colloquial advice "know the audience" requires the ability to adapt to a communication landscape and specific audience – that is, drawing on content knowledge and skills unique to each audience. Messaging pertains to the ability to

identify and shape core ideas and supporting information for a communication effort, including the ability to determine content that should be eliminated or contextualized in service of clarity or relevance. Language alludes to the myriad ways that words can promote or inhibit understanding of information and ideas being communicated. Narrative enables communicators to organize the content and information into a logical and compelling thread to promote understanding of, engagement with, or shaping of beliefs and feelings about the material. Design applies to the ideation and creation of any kind of supportive element that complements verbal or textual content (this is frequently visual in nature but is not limited to that sensory domain). Nonverbal communication connects the deliberate use of vocal dynamics, faces, hands, and bodies to supplement verbal communication, while writing style involves the similar analogues for the written word. Finally, creating space for dialogue through listening, empathy, and audience engagement refers to the collective sets of practices that open up space for responsiveness and interaction in a communication or public engagement effort.

We propose that each of these skills can be further sub-divided into different elements, which are outlined in column 2 of Table 1. Further detail about the elements of each foundational communication skill category are outlined in column 3 with example questions to contextualize and illustrate approaches and information types. For example, adapting to a communication landscape and audience requires that a communicator be able to obtain relevant information about the context and audience makeup for the communication effort and develop an understanding of the audience's goals/motivations, background/areas of expertise, beliefs, and values. Acquiring this information similarly requires that the communicator be willing and able to do advance prepwork as well as plan for and adapt to information that (s)he can glean from the audience in real time.

Each foundational communication skill category is inextricably shaped by the audience (or partner in the public engagement effort), and as such, a core element of each skill category relates to the alignment of the audience's needs and goals with the choices a communicator makes in an engagement context. See Box 1 for a real-world example of a scientist-communicator engaging with different public stakeholders, including a reflection about how these different stakeholders impact her choices before and during the engagement efforts. We propose that systematically addressing whether these choices align to the communication context, goals, and audience should be one core element of training scientists to become effective communicators.

The practical and research basis for foundational communication skills

Each category has a rich body of theoretical and practical advice associated with it deriving from different fields, including communications, marketing, informal science education, and entertainment, to name a few. As a result, few communication training programs systematically cover every category of skills, and an evidence base supporting the importance of each category is inconsistent or lacking. Moreover, little evaluative research examines how efficacious different training approaches are in helping emerging communicators to master these skills (or even which skills are most important or most lacking in training opportunities). This lack of evaluative research contributes to the significant heterogeneity in different approaches and emphases in training programs.

Box 1

Professor Sheena Cruickshank consistently engages with different groups about the infectious parasites that she researches. Below, she provides two examples of different engagement efforts which were shaped according to the different needs, priorities, and desired outcomes of her public partners and audiences.

Professor Cruickshank writes: "*For activities aimed at families - the aim is to make it fun but have a clear take home lesson. I want to raise awareness of worm infection but also equally the important message that hand washing is essential and universal in preventing infection--parents and teachers really appreciate this message. We connect with our family audiences by making it relevant to them, including by talking about other tummy bugs like norovirus that they will have experienced.*

Importantly, our team incorporates different levels of detail and information that are appropriate for both young and older audiences, especially with groups containing a mix of age groups. One example is the way we teach about parasite life cycles and the impact on infection. We have simplified some parasite life cycles to roughly three key stages and made a cartoon version of it - these can then be used to create jigsaws for game play and discussion, especially for younger audiences (images below). I will also have 3D-printed props and specimens of the actual worms with me, and we often use infographics about infection. The cartoon life cycle was made into an animated video with audio that we designed to be 1-minute long (https://www.youtube.com/watch?v=7Wlg19LTre4https://www.youtube.com/watch?v=7Wlg19LTre4). To help articulate the importance of hand washing, we may use a further set of props - such as GlowGel, a luminescent powder or gel that was designed to educate health workers about good hand washing - to discuss/illustrate infection spread. We may play games that let young learners investigate who is the origin of the "infection" and get them to test their hand washing skills.





We do different things with adults learning English. We use less game play, and as the students are in a classroom setting, there is an expectation they are here to learn. The students are both learning a language and learning about parasites and infection, therefore we must provide key vocabulary. We use images to help with understanding, and recordings of the words are essential so that people can hear how they sound. We encourage peers to share words in their own language(s) to help reinforce their learning. We will discuss words or terms they are unsure of and encourage them to apply them to sentences. Finally, their understanding and ability to use the new words in the case studies is assessed by asking questions based on the text we provide and getting students to write sentence answers that they will read out in class. This enables students to hear, say, and use the new words.

In this online lesson, I provide vocabulary and a lesson sheet that had phonetic sounds and online actual recordings of the word alongside an application of the key science word in a sentence. I then created a story about worm infection and the learners had to answer questions after as well as write sentences using the words. https://www.softchalkcloud.com/lesson/serve/5xBpEdNm3W2Y4Q/html?_ga=2.185909609.1124994513.1551345948-1589805287.1551345948"

Notice that Professor Cruickshank finds ways to talk about parasitic infection while centering the needs of both her audiences, and this shapes her engagement effort. With family groups, she emphasizes the importance of hand-washing, while with English language learners, she focuses on creating multiple ways for students to interact with the new scientific vocabulary. These differing needs shape her messages, language, and the types of activities (including visual aids, props, games, etc.) that she uses during each engagement effort.

We have organized Table 2 to highlight the multitude of both general learning and skill-specific resources. In an attempt to differentiate resources focused on both practical advice and the research basis supporting the value or impact of each of these skills, we collected practical literature and/or resources into column 2 and organized evaluative or research literature into column 3. The plethora of these resources - including many others not listed in the table - highlights the importance of the field, the hunger for developing practitioners to find avenues to develop their skills and practices, and the somewhat disconnected (and unevenly distributed) landscape of resources designed to facilitate training and preparation. Notably, some areas have particularly unbalanced distribution of resources in the practical versus research/evaluative literatures (e.g., storytelling has a multitude of practical resources but relatively few research/evaluative resources, while nonverbal communication shows the opposite pattern). There is a clear need for thoughtful and consistent integration to better prepare scientists for communication and public engagement opportunities.

Table 2 also points to an additional observation: more work should be devoted to developing validated and evidence-based approaches to evaluating the efficacy of different training content and exercises in fostering specific skills. Early pioneers have begun this task. For example, Baram-Tsabari & Lewenstein (2013) described an instrument to assess written communication skills and define benchmarks to describe a learners' mastery of those skills. This valuable contribution also presents an opportunity for expansion: we propose that instruments like this one should be bolstered to encompass other channels of communication (including oral communication) and additional skills not included in the instrument. Additional instruments have been developed to assess participants' feelings about their training experiences, with an emphasis on the impact of training on self-efficacy (Evia, Peterman, Cloyd, & Besley, 2018) and outcome expectations (Peterman, Evia, Cloyd, & Besley, 2017). Taken together, these different types of instruments probe different aspects of the training experience, and both are valuable in considering how different programs impact aspiring science communicators and engagers. We encourage the wider development and adoption of instruments which both assess the effectiveness of a training approach in preparing communicators to skillfully apply different skills (and the impact of the training directly on the ability to engage effectively with audience members) and instruments which assess how a communicator feels about future public engagement efforts.

Real-world examples of different approaches to training foundational communication skills

By means of demonstrating both the heterogeneity of different training approaches and the opportunity to foster innovation by sharing the value of different training perspectives, we highlight how different organizations or individuals have tackled teaching one core foundational skill: messaging.

COMPASS created the Message Box (COMPASS Science Communication, Inc., 2017) and accompanying workbook to help communicators define a core "issue" or message for science communicators. The box has five sections, which can be completed in any order once the communicator has defined their audience. The five sections include: Problems, Benefits, Solutions, So What, and Issue. The Issue section defines the overarching topic of the communication effort, ideally in one sentence. The Problems section defines the specific research questions or expertise-related problems to address in the communication effort.

The Solutions section outlines the possible solutions to the problem(s) that the communicator outlined, while the Benefits section helps the communicator articulate positive outcomes of bringing the solution to reality. The So What section gets to the issue of why the content of the communication effort is important and why the audience might care about it. COMPASS encourages communicators to fill out their message box and then refine it, prioritizing information included so that each section contains two or three points. They also recommend returning to the center Issue section if it was filled out first to determine if the focus has changed at all based on filling out the other sections of the Message Box.

RELATE grounds messaging instruction in finding the single core message that is aligned with both the communicator's and audience's goals and needs during an engagement opportunity (Aurbach et al., 2018). This instructional approach begins with communicators' non-linear brainstorming, where they capture as many ideas and content elements related to their topic as possible. Next, communicators use Half-Life Your Message (HLYM) to discover a single core message by speaking aloud and iteratively for one minute, then thirty seconds, then 15 seconds, then 8 seconds on their topic. Finally, communicators are encouraged to evaluate their central message for its alignment with their goals and their audience's goals, and whether they like the resulting message (HLYM can be an iterative process if it is deemed that the message achieved at the end is not satisfactory). From there, communicators can examine their longer versions of HLYM and their non-linear brainstorms to surface how different ideas cluster into supporting themes and/or narrative elements. Communicators aim to eliminate unnecessary information and scaffold important ideas such that they support the core central message of the communication effort.

The AAAS Communicating Science program focuses their messaging instruction on the "3 Ms" structure. AAAS encourages communicators to find messages that are miniature (short and simple), memorable, and meaningful (particularly to the audience). They recommend that communicators identify three ideas with which to engage the audience, then focus the communication effort around ensuring these three points align to the "3 Ms" guidelines. The three points should be miniature, or short, so that the scientist and the audience members can easily remember them. Tools to make these messages memorable include using alliteration, creative language, patterning or visualization of the three points. Ensuring the message is meaningful involves defining the audience and what might be important or relevant for their lives. It also provides an opportunity for communicators to express why certain topics are meaningful to them while staying relatable to the audience. AAAS suggests that having a three-point message helps speakers to: organize their communication efforts, adapt on the fly to provide more or less detail around each of the three key points, and provide a device to help get back on track if a speaking effort requires reorientation.

Each of these approaches to messaging focuses the communicator on thinking about what will be meaningful for their audience and eliminating extraneous information but addresses this overall goal with different training methods and recommendations. We note that these approaches each provide different kinds of value and are not mutually exclusive. To our minds, this reinforces the value of supporting a wide field for experimentation with training approaches while also working to define a field-wide coherence for important competencies and approaches to evaluate the success of different training strategies.

Discussion

Effective communication enables meaningful engagement. People can communicate without engaging, but the converse does not hold: people cannot engage without communicating. To work towards a system which better supports scientists in their efforts to pursue engagement work, we have distilled this outline of component foundational skills we believe underlie effective communication. We hope that the science communication training and research community can use and improve this framework to develop greater coherence across the field as we work to deploy the most effective approaches to equip scientists to acquire and leverage these skills.

One beneficial quality of foundational communication skills is that they deploy regardless of context or audience, arguing that they should be incorporated into undergraduate and graduate training (Brownell, Price, & Steinman, 2013). Indeed, developing these skills are core elements of early-career preparation for any professional trajectory, and can be used across contexts including professional, academic, and interdisciplinary communication (Alpert, 2016). Importantly, these skills can be taught and developed over time, pointing to the value of training programs embracing effective curricula to strengthen scientists' communication muscles, ideally beginning with early-career opportunities.

One approach to encourage the adoption of this value might be to establish "core competencies" related to training efforts supporting science communication and public engagement. Agreeing on and articulating the core competencies - and establishing metrics to evaluate and measure these competencies - will yield a number of important benefits. Articulating core competencies can guide trainers in developing programming and encourage the more widespread adoption of communication training. One model to this end might be to continue to leverage the work begun by Baram-Tsabari & Lewenstein (2017), establishing in more detail the other core learning objectives as we have begun to articulate here for their third learning goal. Moreover, articulating these core competencies will help scientists and other groups to act as more informed consumers when contracting with trainers who provide opportunities to develop these skills.

Moreover, we propose that our field should collectively explore and define a journey map that tracks the progression of scientists who are new to public engagement as they develop these skills and a public engagement practice over time. We propose that such a journey map would benefit from the articulation of the foundational communication skills we have named and organized here, especially as other stages for development of these skills might be named and articulated. These other stages might include an exploration of how early practitioners discover public engagement with science and become motivated to get involved, the different pathways that scientists might take in pursuing public engagement with science, and the types of practice opportunities which are important and impactful in helping learners to achieve mastery in their chosen area for engagement work. Such a journey map might be useful in a number of regards, including: articulating core competencies for science communication and public engagement, differentiating the stages of development as a scientist progresses from a novice through to achieving mastery and developing a public engagement practice, helping to categorize how different training opportunities might benefit learners at different stages of development, and grounding evaluative instruments used to measure the impact of those trainings.

While we hope that articulating this view of foundational communication skills will help our field to advance towards greater coherence, our observations do not address some important questions. Are these the *right* foundational communication skills, or does this organizational framework primarily reflect the prevailing - if disjointed - popular advice? Relatedly, will the evolving forms of public engagement with science inform the definition of what communication skills are foundational? How should these foundational communication skills be trained? What other skills are important for effective public engagement with science (e.g., the value of being perceived as warm and competent, Fiske, 2012; 2016), and how might we refine our thinking to consider these as foundational, too? Moreover, given that the majority of scientists pursue academic training, our field should better consider the integration with those curricula. Does learning foundational communication skills occur in discipline-specific training, and if so, how is that training embedded in disciplinary curricula? Can the field of public engagement enhance that training or vice versa? And finally, given limited time and resources, how should we prioritize training approaches to ground scientists with effective communication skills? Are some skills more important for successful communication and public engagement efforts than others? How might we evaluate this?

We believe that moving towards coherence in designing science communication and public engagement training programs will help to address the issues created by our current “Wild West” approach. In defining our view of foundational communication skills here, we hope to advance this conversation and work towards greater consistency so that our field might create clear avenues for scientists early in their practice to become effectively prepared and impactful with their public engagement efforts.

Table 1: Foundational science communication skills, their category elements, and example questions

Foundational Science Communication Skill Category	Category Elements	Example Questions by Element (non-exhaustive)
Goals and Objectives	Visioning success	If the communication or engagement effort was successful, what would happen? What signals or measurement would indicate that the effort was effective?
	Goal identification and audience alignment	Given the communication context, what is a reasonable ultimate goal that the engagement work is intended to achieve? What goals might other stakeholders enter with? Are these appropriate and/or aligned?
	Communication objective segmentation	Can the objective be broken down into more concrete elements which indicate whether the effort is successful? What other goals might come into play for the communication effort? How are these different from the specific objectives and tactics that might be used in the specific communication effort?
Adapting to a Communication Landscape and Audience	Audience choice	Why this audience? Why now? Why this context/space/channel?
	Logistical	How many people? How much time? What format?
	Expertise	What type of background in the content is the audience likely to have? How can you connect to and build on what they know?
	Values and core beliefs	What matters deeply to the audience? What beliefs about norms, oneself, and/or other people might be at play? Are there likely to be charged or controversial topics which challenge audience values that might get raised?
	Understanding historical contexts and inequities	What previous experiences has this audience had with scientists? Are there sensitive issues or contexts which might impact trust or other elements of relationship-building?
	Sources of information	What can be gleaned from event organizers? What must a communicator assume and/or make an educated guess? What can be determined in real time (e.g., using tools like straw polls)?
	Goals and motivations	Why did the audience show up? What are their expectations? How will the audience use the information? Do these factors align with the communicator's goals and objectives?
Messaging	Message prioritization & distillation	What is (are) the core message(s) to communicate for this audience? Must this message be crafted from scratch or are there pre-developed effective messages that I should amplify?
	Grouping like ideas; supporting key messages	What are the key elements or pieces of evidence necessary to support the core idea? How can information be grouped to maximize coherence? What is extraneous information to be eliminated because it's not relevant or useful to audience?
	Goal and audience alignment	Is this message appropriate to my communication goal? Is this message appropriate for my audience? Does this message align with what my audience needs, wants, or expects from this interaction?
	Recognizing "science language" including jargon; using plain language	What words and vocabulary should I use to advance my goals? How can I effectively contextualize and define words that may be new to my audience?

Language	Literary or linguistic tools	Are there analogies, metaphors, descriptive examples, or other tools which I can use to make abstract ideas more concrete?
	Goal and audience alignment	What are the "languages" that my audience speaks? What words or concepts are important or familiar to my audience? How can I reference or incorporate those words or ideas into my discussion?
Narrative	Organizing information	Am I conveying all the information I need to tell the story? Is my information sequenced in a logical way to tell my story? Do I have all the necessary information to tell the story?
	Compelling storytelling elements	How can I make my story meaningful and compelling to them? Does my sequence build and release tension? Are there tools which I can employ (e.g., personal stories/anecdotes, analogies/metaphors/visual imagery, etc) to connect? Are the tone and frame in keeping with my goals?
	Goal and audience alignment	Is this narrative appropriate to my communication goal? Is this narrative appropriate for my audience? Does this narrative align with what my audience needs, wants, or expects from this interaction?
Design	Design principles	What is the color story? How can I use whitespace effectively? Flat/cartoon, hand-drawn, or dimensional design style?
	Graphical storytelling	What is the core message of this design? Where are the focal points & how does information flow in this design?
	Representing data	What kind of visual would best represent my data/study compellingly and accurately?
	Goal and audience alignment	Are my visuals appropriate for my audience? Do they align with what my audience needs, wants, or expects from this interaction?
Nonverbal Communication	Posture	How can I position my body in space to express confidence, warmth, and openness? How and where should I move through the space?
	Gesture	How can I use my body and hands to add emphasis to my words and visuals?
	Expression	How can I use my face to convey emotion or add emphasis to my words and visuals?
	Vocal dynamics	How might I use different vocal tools, including pitch, pace, volume, and rhythm, to help make my oral communication dynamic and engaging?
	Goal and audience alignment	Are my nonverbals appropriate for my audience? Do they align with what my audience needs, wants, or expects from this interaction?
Writing Style	Grammar	Am I using appropriate and correct grammar for my audience?
	Voice and tense	Am I using active voice and/or descriptive verbs? Am I speaking in the present tense?
	Sentence structure	Am I using declarative sentences? Am I posing questions where appropriate?
	Clarity	Are my sentences compact and clear?
	Tone and formality	Does my personality come across? Is my tone and the relative level of formality appropriate for the audience and communication context?
	Goal and audience alignment	Is my writing style appropriate for my audience? Does it align with what my audience needs, wants, or expects from this interaction?

Creating Space for Dialogue: Listening, Empathy, and Audience Engagement	Recognizing historical inequities that have previously excluded audiences	What audiences have been excluded in the past? How can I acknowledge privilege? How can I integrate equity and inclusion into my communication effort?
	Listening	How can I create space to evoke engagement with my audience? What questions can I ask or discussions can I prompt to promote engagement? How can I convey that I am listening & open to understanding their thoughts (e.g., with active listening or mirroring)? What might I learn from my audience?
	Demonstrating openness and warmth	How can I sincerely embody and communicate the willingness to connect on a human level? How does or might my body language, voice, or writing convey warmth and openness? How might I stay open-hearted/wholehearted to listen and respond to my audience without defensiveness if a discussion becomes tense?
	Cultural relevance and humility	Are my frames and examples appropriately situated in my audience's social, cultural, and environmental contexts? If I do not belong to the same social or cultural groups, how might I express humility and a desire to connect and learn from my audience?
	Promoting dialogue	What questions might I ask of my audience? What can I learn from my audience? How might I incorporate what I learn from the audience into this interaction and future interactions?
	Recognizing audience attention as it ebbs and flows	What nonverbal or verbal signals can I pick up on to determine how my audience is responding to me? How can I change my approach to maintain energy and flow?

Table 2: Practical, research, and evaluative resources for foundational science communication skills

Foundational Science Communication Skill Category	Relevant Teaching Resources and Practical Literature	Relevant Research and Evaluative Literature
Overview resources & books covering multiple skills	Stein & Daniels, 2017; Baron, 2010; Bowater & Yeoman, 2012; Dean, 2012; Doumont, 2009; Meredith, 2010; Olson, 2009; Walters & Walters, 2010; Falk, Dierking, & Foutz, 2007; Illingworth, 2017	Evia, Peterman, Cloyd, & Besley, 2018; Jamieson, Kahan, & Scheufele, 2017; Peterman, Evia, Cloyd, & Besley, 2017; Crone et al., 2011; Brossard & Lewenstein, 2009
Goals and Objectives	Dudo & Besley, 2016; Dudo, Besley, & Yuan, 2017	Besley, Dudo, Yuan, & Abi Ghannam, 2016; Besley, Dudo, & Yuan, 2018
Adapting to a Communication Landscape and Audience	Huertas, 2016	Bergsieker, Leslie, Constantine, & Fiske, 2012; Sommer 2006; Nisbet & Scheufele, 2009; Dietz, 2013; Dawson, 2018
Messaging	Aurbach, Prater, Patterson, & Zikmund-Fisher, 2018; COMPASS Science Communication, Inc, 2017; Heath & Heath, 2007	
Narrative	Olson, 2015; Olson, Barton, & Palermo, 2013	Dahlstrom, 2010
Language	Aubusson, Treagust, & Harrison, 2009; Bentley, 2011; Ghose, 2013; Rakedzon, Segev, Chapnik, Yosef, & Baram-Tsabari, 2017; Treagust, Harrison, & Venville, 1998	Sharon & Baram-Tsabari, 2014
Design	Evanko, 2013; Knaflic, 2015; Schwabish, 2016; Tufte, 1990, 1997, 2001, 2006	Valdez & Mehrabian, 1994; Tatalovic, 2009
Nonverbal Communication		DePaulo, 1992; Ableson, Kinder, Peters, & Fiske, 1982; Mehrabian & Williams, 1969; Mehrabian 1968, 1970
Writing Style	Pinker, 2014	Brown, 2018; Moravcsik & Kintsch, 1993; Klare, Mabry, Gustafson, 1955
Creating Space for Dialogue: Listening, Empathy, and Audience Engagement	Alda, 2018; Chang, Simon, & Dong 2012; Simon, 2010	Dupree & Fiske, 2019; Fisher-Borne, Cain, & Martin, 2015; Nisbet, 2009; Riesch, 2015

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