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A guide to science communication training for doctoral students

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Effective science communication is necessary for engaging the public in scientific discourse and ensuring equitable access to knowledge. Training doctoral students in science communication will instill principles of accessibility, accountability, and adaptability in the next generation of scientific leaders, who are poised to expand science's reach, generate public support for research funding, and counter misinformation. To this aim, we provide a guide for implementing formal science communication training for doctoral students.

"We have not known a single great scientist who could not discourse freely and interestingly with a child."—John Steinbeck[1]

Many of us remember our first experience with science, or the first time we heard about a scientific finding that ignited our curiosity. These early experiences draw us in, capture our imagination, and provide us an entry point we may otherwise never know exists. We can attribute these moments that sparked our intellectual curiosity to the science communicators who took the initiative and the accountability to share science with a wider audience. Here, we discuss why and how to set up training for doctoral students to enable them to become the next generation of science communicators, and thereby to expand the future scientific workforce, broaden the public reach of our science, and increase public support for funding for scientific research.

According to UNESCO's 2021 Science Report, there are approximately nine million full-time researchers world-wide[2]. However, with a global population of approximately eight billion, it is imperative that science is accessible to far more than just about 0.1% of the population, creating a global need for communicators. The commodity that researchers and educators exchange is information, and the quality of this exchange depends on our ability to communicate effectively.

We live in an interconnected world with tremendous access to information. This brings both opportunity and risk, as scientific (or pseudo-scientific) information can easily spread through various media platforms. It is imperative that we train scientists to be accountable, accessible, and adaptable, so that they may effectively engage with the public through varied platforms, promote scientific literacy, and mitigate the risks of misinformation[3,4]. Training researchers to communicate accessibly and accurately is instrumental for building trust with a wider audience[5,6]. Indeed, trust is the foundation for greater public awareness, interest, and policy adherence to science-based issues, such as climate change[7] and mental health[8].

Three As of effective science communicators	Key modules
Accessible Convey scientific concepts clearly to a wide range of audiences, regardless of age and background	• Science education • Science writing • Science podcasting
Accountable Foster trust through transparent communication and responsible dissemination of information	• Data visualization • Public outreach • Science policy
Adaptable Use diverse communication tools to reach audiences across media and contexts	• Social media • Improvisation • On-camera presentation

Fig. 1 | The three As of effective science communicators. Examples of the modules used to instil each are given.

If we instill good communication practices in doctoral students, they will be better equipped to inform and influence policy makers and the public. In this way, scientists can foster a rich and vibrant discourse that extends our work's reach and helps to strengthen our society. This is particularly important because many students trained as basic scientists will pursue non-academic careers. According to the US National Science Foundation's Survey of Doctorate Recipients, only 23% of life and health sciences PhD graduates held tenured or tenure-track positions in academia in 2017. Training in effective science communication prepares students for a wide range of careers, including education, the biotechnology and pharmaceutical industries, government, and publishing.

We believe that the essential attributes of effective science communicators can be summarized by the 'three As': accessible, accountable, and adaptable. Accessible communication practices entail conveying scientific concepts to a wide range of audiences regardless of age and background[9]. Accountability requires gaining the trust of the target audience through transparent communication and responsible dissemination of information. Accessible and accountable communication practices construct a bridge of trust between communicators and their audience, facilitating a reciprocal exchange of knowledge[10]. These practices are crucial for sharing knowledge beyond institutional and geographic borders[11]. Proficiency in this process allows communicators to be adaptable to variety of media and contexts for disseminating science[12]. These attributes build on each another to ultimately enhance the effectiveness of science communication efforts (Fig. 1).

Currently, science communication is not a universal component of the curriculum in neuroscience doctoral programs. Our goal in writing this piece is to explain why PhD-level science communication courses are needed, and to share practical information about their implementation. We aim to encourage funding agencies to promote the development of this training, and to allocate resources to support it. The example syllabus we provide (Table 1) is designed to promote accessible, accountable, and adaptable science communication through

Table 1 | Effective science communication course breakdown

Module topic	Objective	Project	Evaluation
Written communication modules			
Science on social media	Learn to develop professional identity and create an online presence for scientific discourse	Creation of a personal website or a social media account for the purpose of conveying scientific knowledge	Feedback on ways to improve their social media presence to appeal to their professional interest
Creating a science curriculum	Learn inclusive teaching techniques for middle school science education	Design of a lesson plan, application of teaching techniques learned during workshop	Quality and relevance of lesson plan, effectiveness of teaching techniques applied
Illustration and visualization	Learn techniques for visualizing data and scientific projects	Creation of graphical abstracts of student's dissertation project	Feedback on figures to improve schematic quality
Science writing for non-science audiences	Learn principles of popular science writing and journalistic reporting	Creation of a science blog post, op-ed, or commentary geared toward non-scientists	Peer review of written pieces and implementation of feedback to improve reader accessibility
Oral communication modules			
Improvisation and on-stage performance	Develop skills in science communication through improvisation, role play, and storytelling	One time participation in on-stage performance of improvisation, storytelling or similar	Improved ability to think creatively about science communication, increased confidence in public speaking
Public engagement in neuroscience	Learn skills for engaging with the public, brainstorm ideas for public engagement initiatives	Development of a strategic plan for a public engagement initiative	Effectiveness and relevance of public engagement initiative
Science podcasting	Learn interview techniques, practice interviewing skills	Create one podcast episode and/or participate in podcast interviewing	Understanding of key elements of science podcasting, quality of interview skills demonstrated
Science policy and advocacy	Learn how to approach and pitch to local government representatives	Plan or participate in a meeting with your local representative to advocate for science	Efficacy of the communication strategy and feedback from meeting with local representative

An exemplar syllabus based on the Effective Science Communication course held at the Icahn School of Medicine at Mount Sinai. This course structure could be adapted to meet the needs of any institution and its students.

didactic lectures and hands-on activities, designed to engage students in best practices for effective science communication.

We have specifically created the 'Effective Science Communication' course at the Icahn School of Medicine at Mount Sinai, which was initiated by students in 2018, and has since been completed by more than 100 students. This is a semester-long course delivered annually to approximately 20 graduate students under the auspices of the Friedman Brain Institute at Icahn Mount Sinai. We strive for this material to be delivered in a classroom setting that is respectful of each student's comfort and experience with science communication. The class is intended to be a safe space for students to practice new skills while receiving supportive feedback from experts across various domains.

As an exemplar course structure (Table 1), there are two sets of modules, representing the two forms of communication: written and oral. In each set, four modules focus on different media for communicating one's science. Each module consists of two parts — theoretical work and a hand-on workshop, which could be delivered within a 3-h session. We emphasize hosting speakers who reflect diverse personal and professional backgrounds and identities, and who can best connect with, inspire, and support the students in their development as effective science communicators. Previous lecturers include journal editors, podcasters, journalists, lobbyists, press officers, industry leaders, TV presenters, improvisation and storytelling coaches, and social media experts. Speakers are typically scientists who pursue their preferred mode of science communication either full-time or to supplement their academic research. This allows students to explore alternative career paths or be inspired in ways to productively integrate science communication in their research careers.

Each speaker provides pre-class materials, an in-class hands-on workshop, and an optional post-class assignment. Students can choose one of these assignments as their final class project, which they will develop into a complete product, such as a blog post, podcast episode, science website, elementary school class, or storytelling performance. We expect that by completing this course, students will be able to identify the needs of their diverse audiences, effectively and flexibly convey their research's significance using different media, and maintain the integrity of scientific principles. These skills create a holistic scientist, poised to serve as a changemaker on a global scale.

This course structure could be adapted to meet the needs of any institution and its students. For example, different weights could be put on oral or written communication, on education, or on public interfacing projects. In fact, each of these topics could constitute a course in itself. The emphasis on lectures versus hand-on workshops can also be adjusted according to institutional needs and capabilities.

We hope that these resources will decrease the barrier to entry for institutions seeking to implement such educational programs for trainees. We also hope that students will take this practical framework as a guide for academic development. Students provide feedback before and after the course as well as after each module to track the course's efficacy and to ensure that material is tailored to the students' unique needs and interests. Our goal is to inspire scientists across disciplines to uphold the three As of science communication — accessibility, accountability, and adaptability — when pursuing opportunities to communicate their research and to effectively embed science in everyday life.

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Competing interests

The authors declare no competing interests.