

Abstract: Over the last two years we piloted a professional development program to learn public communication. We found that students want these skills, need these skills to stay competitive, and aren't getting them at CMU. In order to meet this need, we recommend expanding to a university-wide center.

Executive Summary

I. We have much to gain by training STEM students in communication

When we think about the future of the scientific community, we need to consider how we can do more to prepare our graduates to meet future challenges. While we will continue to rely on our core training, we will also need to add new skills and to update our education system so that it prepares STEM graduates for the challenges of the 21st century. The most important skill that we feel is missing from our graduate education is science communication.

II. Programs outside CMU show demand, viability, and gaps

Many people outside CMU have also recognized the need for comprehensive communication training, and begun ambitious new programs. But the landscape is nascent, with many gaps that a program at CMU could fill. Most programs are short, one-shot sessions, which cannot provide the sustained practice and experience that researchers need to develop competency in a new skill set. Graduatelevel training programs have only recently started to crop up, and few offer certification. Theoretical training is rarely paired with practice opportunities, and hardly anyone has combined the enthusiasm of bottom-up grassroots efforts with the power of top-down administrative support. CMU is thus uniquely positioned to lead the creation of high-quality, comprehensive training for graduate students to master science communication.

III. Programs inside CMU do not sufficiently address our needs

CMU has many opportunities for professional development, which are effective at bringing students up to a common standard of communication within their field. What these programs do not attempt is to help students acquire the more advanced skills they would need to discuss their work with a wider audience, borrowing from fields of rhetoric, theatre, media training, and sociology. Department-sponsored training operates under the apprenticeship model, in which faculty give feedback based on their own experience. This model is good for sharing common practice, but not for developing best practices for non-academic settings with communication experts. Finally, K-12 outreach shares many of our goals, but including adults in communication offers the potential for more diverse outreach and higher impact.

IV. Public Communication for Researchers shows demand, viability, potential

Rather than wait, we created the workshops that we wanted to take. *Public Communication for Researchers* (PCR) is a pilot program to gauge interest, rally a network of resources, and develop a curriculum for excellence in public communication. In our first two years, we created 9 workshops and hosted 15 events. These workshops have attracted 450 students, a mean of 30 per seminar. For a complete list of workshops and descriptions, please see Appendix A.

We are now at a crossroads. PCR has gathered a large amount of expertise, student involvement, and support, and there are enormous opportunities for growth. But if the program remains a student organization, it stands to face severe challenges of resources and continuity as the founders progress toward graduation.

V. We recommend that CMU establish a center for communicating science

The gaps that we see with communication programs suggest that the best way to teach science communication is by establishing a dedicated center. Campus centers have a strong history at CMU, such as the Eberly Center for Teaching Excellence, and do not need to take up a large physical footprint. A center would serve four primary purposes:

- 1. **Provide instruction** in the form of semester-long courses, *à la carte* seminars, and invited speakers.
- 2. Offer accreditation with a transcript and personalized letter of recommendation, similar to the Eberly center's Future Faculty Program.
- 3. Organize practice opportunities to strengthen skills, provide outreach, and bolster positive publicity
- 4. Serve as a hub for a social community of public engagement

Establishing such a center can start at the graduate level, and then expand to meet the needs of faculty, post-docs, and undergraduates. A center for public communication will prepare our students with the skills they need, enhance CMU's reputation for world-class research, and fulfill our responsibility to the public as knowledge experts.

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I. We have much to gain by training STEM students in public communication

We can enhance our reputation as a research university

Teaching public communication to researchers can help CMU meet the challenges of a growing research university. We can strengthen our research quality and reputation by producing a generation of students who can better explain their research and why it matters. Explaining our research within academia is increasingly necessary as our fields become more specialized, and cross-disciplinary collaboration continues to be a source of innovation.

Communicating our research outside academia can benefit our public image as well as our academic reputation. On the academic side, one study found that articles covered in popular press receive 73% more citations over ten years compared to control articles which were selected for coverage but never publicized due to a writers' strike.¹² More broadly, public communication training can help students better engage with donors to promote fellowships. The products of our work in public communication would be an excellent way to share the excitement of research in CMU's future welcome center. And with a public communication component to their education, our alumni may see their experience as more unique when they consider making donations. If we take this opportunity for leadership in STEM communication, we have the opportunity to enhance CMU's reputation with donors, the academic community, and the public as a strong research institution with articulate students.

We can prepare our students for future careers

Teaching public communication to researchers can help CMU graduates meet the challenges of an increasingly competitive economy. The life sciences illustrate the problem nicely: when the budget of the NIH doubled to \$30 billion a year from 1998 to 2003, the number of biomedical scientists entering the field nearly doubled as well. But permanent job positions failed to match that rate when federal research funding stagnated (relative to inflation) after 2004.³ As a result, today fewer than 14% of life science Ph.D. graduates reach a traditional academic position,⁴ a figure that has been declining steadily since the 1970's.

A strong foundation in science communication can provide a competitive advantage for CMU graduates on every occasion in academia when we are judged by our ability to persuasively communicate complex ideas: at job talks, for broader impacts in grants to funding agencies, in posters at conferences, or in manuscripts to journal editors. If we do land a coveted academic position, public communication will make us better teachers, and help us recruit the best students and collaborators to our research.

We must think beyond academia, as well: if we continue to train graduate students exclusively for academic positions that only 14% may attain after nearly a decade of work, then we are failing 86% of our students. CMU has an opportunity to provide more versatile education to tackle the reality of the job market, and prepare graduates for expanded career options besides tenure-track faculty and the post-doc purgatory. Communication is an essential skill for unlocking more career options, enabling students to transfer their knowledge to industry, promote startups, move to science journalism, or consult on public policy. More immediately, public communication improves our quality of life: it's fun, and it keeps us in touch with the higher purpose of our work that can often get lost in the details of research.

We can fulfill our responsibility to society

Most people outside academia don't understand our work or why it matters. Basic research offers enormous return on investment, but when that research is not understood, it becomes undervalued. When the value of research isn't clear, it remains chronically underfunded. This is especially true in the United States, where the recent sequester cut \$50 billion over the next five years for research. The perception of research concerns us from the perspective of job security, but also as citizens of a world that increasingly depends on science and technology. Teaching public communication gives us the opportunity to be part of a broader social change for public good. A recent editorial in The New York Times by Adam Frank concluded with this call to action:

"My professors' generation could respond to silliness like creationism with head-scratching bemusement. My students cannot afford that luxury. Instead they must become fierce champions of science in the marketplace of ideas."⁵

We have come to believe that is no longer enough for the scientific community to do good work without explaining why it matters. Science and the public need each other, and that relationship requires a great deal of communication. If we instead stay silent on the sidelines, we yield the conversation to those with the most money, not the most information. That is a failure of our responsibility as knowledge experts. In order to secure our scientific future and create a more literate society, we must empower scientists to talk about their work starting at the graduate level.

We have a chance to capture our current momentum

Now is a fortuitous time for CMU to invest in graduate education reform: there are so few programs that we are poised to make a large impact, yet enough programs exist that we can learn from early mistakes, and we would not have to invent a curriculum from scratch.

While there are always risks in doing something that most people aren't doing, there is also a cost of missing this opportunity. We risk playing catch-up with other universities that would receive public recognition for proactively addressing graduate education reform. Our students and faculty would stand out less if we simply meet new standards instead of setting them. We would also lose the momentum of our student group, which has accrued a following of 450 students across 17 departments and all years of study, a good working relationship with speakers and administrators, and national recognition as thought leaders in graduate education.

II. Programs outside CMU show demand, viability, and gaps

All over the U.S., the last decade has seen a significant rise in communication-focused professional development programs for researchers. These programs are numerous and varied, which attests to the the value placed on these skills in the current professional marketplace. At the same time, the limitations of many of these programs highlight the fact that CMU is uniquely positioned to be a leader in creating high-quality, comprehensive opportunities for graduate students to learn and hone communication skills.

Communication courses are growing, but still fall short of demand

Of the communication programs that exist, few are tailored for practicing researchers who want to improve their public communication skills. The most common form is for science journalists, who have significantly different needs.

Increasingly, though, universities are offering STEM graduate students opportunities to earn academic credit for classes on communicating with non-scientists. A number of institutions now offer such courses, including Stony Brook University's Alan Alda Center for Communicating Science, George Mason University, the University of Washington, Cornell University, and Northwestern University. Universities offering less comprehensive training include UC Davis the University of New Hampshire, Portland State University, and Pace University. Notably, nearly all of these courses were started within the last six years. Several of them are currently over capacity. We take these as signs of growing recognition among the academic community that public communication skills are an essential skill for the professional researcher. We expect that such offerings will only continue to multiply, and accordingly that graduates of Ph.D. and master's programs will increasingly be expected to possess the skills these courses teach.

Despite this increase in programming and demand, only two of the programs – George Mason and Stony Brook – offer any form of certification, and the Stony Brook certificate is specifically focused on health communications. This gap would make a new certification program at CMU especially valuable.

Students are self-organizing, but face challenges in continuity

Academic courses are most often organized from the top down, with administrators and faculty perceiving a gap in students' education and creating a course to fill it. But many universities have been slow to address this particular need, leading students to take public communication training into their own hands. Outside CMU, there are now at least four studentrun seminar series and workshops that provide public communication training for STEM graduate students:

- ENGAGE, a student-run course and speaker series at the University of Washington
- The Scientists with Stories project (SwS), a multimedia workshop at Duke University and The University of North Carolina at Chapel Hill
- ComSciCon, a student conference at Harvard
- The Broader Impacts Group (BIG), a student group at Woods Hole Oceanographic Institution

Much like the university courses, every one of these programs was founded within the last four years. Graduate students, too, are beginning to reach the conclusion that public communication constitutes a key skill set for their careers. When their universities fail to provide training, students are sufficiently motivated to expend significant amounts of time and effort to ensure that adequate training is available. Unfortunately, leaving this essential component of graduate education to efforts of students presents serious problems of resources and continuity, as discussed below.

National recommendations are on the way; we might as well lead

The NSF has taken notice of the growing appetite for public communication training among STEM graduate students. As suggested by the efforts listed above, there are quite a few training programs in existence, but so far they have largely existed completely independently, with little communication or sharing of best practices. They also remain small and local in scale. The NSF saw unifying and scaling up these trainings as a key component of its broader effort to modernize graduate education.

In order to determine the best way to modernize graduate education, the NSF enlisted the help of COMPASS, a national organization devoted to connecting scientists with policymakers and the media. Since mid-2013, COMPASS has been organizing an effort dubbed #GradSciComm, which aims to develop a "collaborative and strategic vision for building systemic communication capacity among STEM graduate students." The program's goals include mapping existing landscape of programs, building a roadmap for scaling up communication training across the U.S., and assisting universities and other related organizations in implementing this roadmap. The roadmap is being drafted by a team of 30 experts representing institutions including the NSF, OSTP, NAS, NRC, NIH, and AAAS, as well as major universities such as Stanford and Cornell.

The PCR board has been working closely with COMPASS in this effort. At COMPASS' invitation, we sent a representative to the recent workshop convened by COMPASS to brainstorm the key ingredients of the roadmap, and we are continuing to collaborate with them on writing the roadmap document. In this way, CMU is already directly involved in driving the national agenda on incorporating communication into graduate training. By investing now in its own public communication program, it can remain at the forefront of this national movement.

Professional organizations provide training, but not sustained practice

Universities are not alone in recognizing the need for public communication training, and it is not only graduate students who need it. Professional societies have also started offering communication training as a professional development service, often to researchers further along in their careers, and several dedicated training organizations have sprung up to meet the need. Among the organizations offering professional training sessions are the National Science Foundation (NSF), COM-PASS, Stony Brook University's Alan Alda Center for Communicating Science, and the American Association for the Advancement of Science (AAAS).

Participants have reported that these workshops are immensely valuable, and many of the organizations have difficulty keeping up with demand. However, most are short, one-shot sessions, which cannot provide the sustained practice and experience researchers need to truly become comfortable with their communication and outreach skills. Such extended training is typically only available in the context of graduate school.

The popularity of these professional workshops is another indicator that public communication is becoming ever more prominent in the zeitgeist of the scientific world. Even among later-career, more established researchers, public communication is now seen as an essential skill for researchers – and essential skills for researchers are the very thing that graduate education is designed to impart.

III. Programs inside CMU do not address our needs

CMU boasts several communication-related efforts besides PCR, most of which aim to help students improve their communication within their academic disciplines. Many are quite effective in this domain, but these programs are not designed to address communicating outside academia, which requires a somewhat different skill set (see Appendix A). As with programs outside CMU, the elements that these programs do *not* attempt to include highlight the opportunities to build on their efforts.

University-wide centers are models for teaching communication, each with a different focus

CMU's communication training consists primary of three centers:

- The Global Communication Center (GCC), established in 2012, provides tutoring services and seminars to help with written, oral, and visual communication, primarily for class projects but also for research-related documents and presentations.
- The Intercultural Communication Center (ICC) exists primarily to help nonnative English speakers and international students interact with their academic environment.
- The Eberly Center for Teaching Excellence provides a variety of services to help students improve their teaching, including one-on-one feedback, seminars, and a certificate program (the Future Faculty Program).

These programs provide invaluable services in the domains of academic communication, cross-cultural communication, and teaching, respectively. They are particularly effective at bringing many students up to a common baseline of communication ability necessary for work in their fields; the GCC's personal tutoring services have proved especially helpful in this regard. This effectiveness and robustness underscores what can be done with sufficient university investment: it has been made possible by significant resources, including full-time staff, paid student tutors, and publicity among all departments.

What these programs do not attempt to do is to help students acquire the more advanced skills they would need to discuss their work more widely. The realm of communication with broader audiences is precisely where there is a clear opportunity to build on existing efforts – to incorporate training in a wider variety of techniques, aimed at students with a particular drive for communication who want to go beyond the class report or grant proposal.

Each of the existing programs has a fairly specific mandate, and each has essentially saturated its capacity just on its area of specialty. But by pouring comparable resources into *public* communication training, the university can build on and expand its existing offerings, providing its students with extended communication skills such as storytelling and media interaction. This will enable students to represent their research and CMU outside academia, prepare them better for nonacademic jobs, and help slake society's thirst for better scientific information.

School- and departmentsponsored training: a mixed bag

In addition to the university-wide centers, several schools and departments offer their own forms of communication classes. For example, the Machine Learning Department requires its Ph.D. students to take a journal club class, in which students receive feedback on their presentations, and Civil and Environmental Engineering students are required to take a professional communication course. Almost universally, such classes are concerned entirely with communication within the field, and therefore leave unmet the same needs as the university-wide centers. They are also often based on an apprenticeship model, where faculty members give feedback based on their own academic experience. This contrasts sharply with the model used by the centers, as well as the model we are proposing, in which communication experts work with students to incorporate best practices into their communication.

The two major exceptions are the Tepper and Heinz schools, both of which offer their business and management students acting and improvisation classes to help them connect more directly with their audiences when communicating. Tepper also runs a leadership and communication development program called Accelerate, which offers one-on-one communication coaching and occasional communication seminars. These forms of training develop many of the same more advanced communication skills that we would like to see available to all STEM graduate students. Presumably, such training has been implemented in business-related programs largely because versatile communication skills are seen as a core skill in the business world. We would argue that the same increasingly holds for those entering STEM careers.

Even these more advanced programs focus mainly on communication scenarios specific to business contexts, e.g., managers speaking with teams. Their students would be equipped to communicate even more widely with additional training on transferring those skills to contexts of public discourse and audiences outside their workplaces. Of course, these existing offerings are also limited in the sense that they are available only to students in those particular degree programs.

K-12 outreach: similar in some ways, but with different goals

Many graduate students participate in another category of activities that is often associated with public communication: K-12 outreach. CMU hosts a number of outreach activities, often student-organized – the *Science Teachers Club* in biology and *TechNights* and *SCS Roadshows* in computer science, to name just a few. Many of CMU's outreach efforts are coordinated and assisted by the Leonard Gelfand Center for Service Learning and Outreach. K-12 outreach programs such as these are often the first thing to come to people's minds when we speak of communicating outside the ivory tower.

It is true that many of these programs share PCR's goals of creating a scientifically literate society and inspiring interest in science. But the types of communication for which we hope to train students differ in several important ways. First, we see communicating with K-12 audiences as just one of many forms of public communication with non-experts. More fundamentally, most K-12 outreach programs have the implicit or explicit objective of inspiring future scientists and engineers. While this is a noble goal, it is not the one we hope to achieve. Rather than having researchers convince others to consider similar careers, we aim to train researchers simply to share the core ideas, significance, and beauty of their work, even with adults in careers completely unrelated to science. For most researchers, it is communication of this sort that offers the most powerful route to boosting their own careers, raising the profile of their research and universities, and raising the prominence of science in the public marketplace of ideas.

When we wanted to learn more about public communication, these groups on

campus were the first place we turned. While they are phenomenal resources, we found that they don't offer the skill sets we were looking for, so we started *Public Communication for Researchers*.

IV.PCR provides a strong foundation for a nationally competitive program

Public Communication for Researchers is the response of CMU's graduate students to the need for public communication training. PCR was launched in 2012 as a grassroots initiative, and has since offered 15 seminars and workshops to over 450 graduate students.

In the process, PCR has garnered wide support from not only students, but also faculty, department leaderships, administrative staff, and other communication training centers on campus. We have gathered significant know-how, and collaborated with communication experts both within and outside CMU to develop a program informed by the latest research and best practices in the field. We are also externally recognized as a strong up-andcoming program: we were invited as "thought leaders shaping the future of science communication training" to participate in the NSF-funded #GradSciComm initiative at the National Academy of Sciences.

We believe we are at a crossroads. Given the internal and external momentum, we believe CMU faces a unique opportunity to invest in public communication and grow PCR into a fully-fledged, nationally competitive program. This would place our university at the forefront of a national movement for making public communication part of graduate education.

We've garnered support from graduate students, faculty, and administration

The most important question for a program such as PCR is whether students are interested in the training. Public communication skills are clearly useful, but are they sufficiently high-priority that graduate students will take time from their busy schedule? Our experience demonstrates that the answer is a resounding yes: Since 2012, more than 450 students have attended PCR events. Our seminars and workshops regularly attract 30-50 students, with our most popular events reaching audiences of 150-200 students. Our participants span every STEM department at CMU, and every academic year. Furthermore, we are both retaining more than half of our participants between seminars and continuing to attract new students.

We are also seeing increasing endorsement from outside the graduate community:

- Faculty from more than seven departments have attended PCR seminars. Others have recommended our events to their advisees, as reported by students participating in PCR.
- CMU schools and departments are supporting PCR: both SCS and CIT have provided funding in the past, with the SCS administration informally committing to annual funding. Many other department have expressed their support and helped promote our events.
- Existing communication centers on campus have provided mentoring and support:
 - GCC are working with us to share expertise, and have nominated PCR for the graduate student awards.
 - ICC are also working with us to share expertise, and attending each of our seminars.
 - The Eberly Center is helping us develop our curriculum.
 - The Gelfand Center has provided funding for our outreach initiatives.
- The CMU administration has provided strong organizational support. In particular, the Office of the Assistant Vice-Provost for Graduate Education provided critical seed funding in 2012, and has supported and mentored us ever since in our mission to establish a longlasting presence on campus.

We've developed a rigorous program informed by research and best practice

There is a great amount of public communication expertise available at CMU and other institutions, but it has not previously been centralized and made accessible to graduate students. Our goal at PCR was to tap into this expertise, bringing it together in a coherent program that encompasses theory, practice, and feedback.

To this end, we have collaborated with:

- Instructors of science communication: We periodically exchange curricula and best practices with the Center for Communicating Science at Stony Brook University, the COMPASS organization, public communication instructors for the American Association for the Advancement of Science (AAAS), and multiple student organizations at other universities.
- **Practitioners** of science communication: Some of the direct beneficiaries of a strong public communication program at CMU have also been our most enthusiastic supporters. These include the CMU Media Relations Office, science journalists from The Pittsburgh Post Gazette and Science Magazine, and the outreach and education staff at the Carnegie Science Center. These practitioners have brought in their experience from the trenches, helped shape our curriculum, and continue to teach some of our core seminars — see Talking to the Media and Telling Science Stories (Appendix B).

- Researchers of science communication: Scientists have repeatedly attempted to contribute their voices to significant public debates on topics such as climate change, GMOs, and vaccination. The mixed results they have obtained have intrigued and frustrated researchers for decades, and have led to a rich but not widely known body of research on what works and what doesn't in public communication. PCR has reached out to some of the leading voices in this field, such as the Cultural Cognition Project at Yale, and we are one of the first organizations to incorporate their material into our seminars and workshops — see Why are facts not enough? (Appendix B).
- Communication experts from other fields: While public communication of science is rapidly growing as a field, there are many other disciplines with a long history of success in persuasive and engaging communication. We bring in expertise from the writing, rhetoric, and theatre departments to further create training which passes the test of real-world practice — see *The Science* of *Scientific Writing*, *The Art of Argument*, and *Improvisation for Scientists* (Appendix B).

Incorporating elements from all these sources, we have planned out a comprehensive public communication curriculum we are working to gradually implement at CMU (Appendix A).

This program's potential cannot be realized by a student organization

As a young program, PCR has had great success in generating internal momentum,

accumulating know-how, and developing a network of external support. As we push the program further towards maturity, however, we are becoming keenly aware of the limitations of a grassrootsonly model.

We have a strong vision of what high-quality training in public communication looks like, but we do not have the financial and human resources to implement it. If we had the resources of a campus center, we would recruit more speakers, invest more time with them to create a coherent curriculum, develop exercises and practice opportunities for our students, assess the success and impacts of our programming, keep up with current research and developments in science communication. We have many opportunities to expand: faculty have asked us to run similar programs for them, and we expect there would be extensive interest among undergraduates. But as graduate students with research and teaching commitments, we simply cannot invest the time necessary to implement these changes. We have kick-started the process, but we are reaching capacity.

We are also concerned about continuity. Leadership transitions in student organizations are notoriously dangerous: one generation with weak leadership is sufficient to wipe out whatever expertise and momentum that the organization has built up. This challenge of finding and training new leadership is currently threatening several other grassroots communication programs, such as ENGAGE at the University at Washington. To ensure continuity and growth of a program such as PCR, it is critical to go beyond a student-only model and involve long-term staff.

Now is our chance to be at the forefront of a national movement

PCR is not alone in highlighting the importance of public communication training for universities, students, and society at large. There is growing interest in public communication nationwide, recently crystallized into the powerful, NSF-funded #GradSciComm effort to create a roadmap for making public communication part of the U.S. graduate education. Through PCR, CMU is currently involved in the #GradSciComm effort, and enjoys recognition as one of the actors shaping this growing movement.

We believe this is a critical moment. By choosing to invest in public communication training now, CMU has the opportunity to become a national leader, recognized as a visionary university that gives its graduate students the skills for the academia, marketplace, and citizenship of the 21st century. PCR provides a solid foundation for such an investment, and we outline below a recommended 5-year plan for growing this initiative into a fully fledged, university-supported, public communication center.

V. A 5-year plan to create a public communication center at CMU

We recommend that CMU create a public communication center, modeled on the existing Global Communication Center and Eberly Center. Such a center would have the necessary financial and human resources to provide high-quality training, and would become a useful resource to graduate students across all CMU departments. In time, we envision the center also expanding to serve undergraduates, postdocs, and faculty.

The Vision

We envision a public communication center which acts an active hub for instruction, accreditation, and practice in public communication.

1. Instruction: A combination of semester-long courses, à la carte regular seminars, and one-time invited speakers

A public communication center could offer instruction at multiple levels of depth, corresponding to different levels of student commitment. For most students, the center would offer a-la-carte seminars and workshops on a plethora of different public communication topics, such as distilling your message, making your communication accessible to different audiences, and talking to the media. Much like the Eberly Center, the public communication center would offer such seminars and workshops every 2-3 weeks, rotating through the curriculum every few years. Students could thus cover significant amounts of material at their own pace, spread over multiple years. For more dedicated students, the center would offer indepth, semester-long courses on the theory and practice of public communication of research. Finally, in addition to these regular training opportunities, the center would periodically invite outside speakers, to introduce a fresh perspective, give students access to other sources of expertise, and experiment with new public communication material.

2. Accreditation: Accreditation would benefit student careers and increase the visibility of the center outside CMU

A public communication center could offer an accreditation to students completing a flexible combination of courses and/ or a-la-carte seminars. Such an accreditation would serve multiple purposes: it would provide extra legitimacy to the program internally, and increase its visibility externally; it would provide motivation for students to join and follow through with the instruction, and help justify their time commitment to themselves and their advisors; and it would improve the job prospects of students graduating from CMU, whether or not they choose to stay in academia. In the long term, the public communication courses could form the foundation of a masters program, or even an undergraduate minor in public communication.

3. Practice: Avenues where students can practice would reinforce communication skills and generate publicity for CMU

A public communication center could offer opportunities for students to test and hone their communication skills in the real world. Such opportunities would often be beneficial not only for the students, but also directly for CMU. The center could:

- work closely with CMU Media Relations to provide media-ready students for science interviews. We have already seen interest from SCS Media Relations, who currently field the majority of interview requests to faculty, but would be interest to expand their net to well-prepared students.
- have its own social media avenues, such as a student-run science blog. If such a blog would gain widespread visibility, it would reflect positively on the university at large.
- collaborate with the Gelfand Center for Outreach, and provide highly-trained students for its K-12 outreach activities.

In the long term, we envision students becoming actively involved in making research across the university as accessible and visible as possible. For example, student volunteers could work with interested research groups to create and promote public-facing research websites.

This would complement existing communication centers

CMU has a rich history of teaching communication skills to its graduate and undergraduate students alike. A public communication training program would complement and enrich existing initiatives. Indeed, public communication shares important skills with academic communication as taught by the GCC and ICC, and academic teaching as taught by the Eberly Center.

However, there are also significant differences, and we believe these differences recommend the establishment of an independent public communication center at CMU. The distinct focus of such a center on external, rather than internal audiences raises unique challenges - challenges of reaching across gaps in information, cultural backgrounds, or value systems. We believe that the distinct mission of such a center is sufficiently important, meets a sufficiently central need of students, our university, and our society at large, that it deserves its own mandate, rather than being addressed by extending the mandate of existing organizations.

Existing communication centers on campus such as the GCC have a well defined mission, which they fulfill exceptionally. The GCC is in high demand, and always working at capacity. Extending its mission to cover public communication would itself require allocating new resources comparable in scale to those necessary to start a dedicated public communication center. Allocating those resources as part of the GCC however risks diluting the central mission of public, external communication. As such, we believe that the best solution is the creation of a parallel and complementary initiative on campus - an independent public communication center.

Administrative Structure

We recommend an administrative structure based on a small core team of permanent staff, working in collaboration with graduate students.

Permanent staff are essential for continuity of expertise, and define the long-term vision of the center. They would be tasked with curriculum development, teaching the courses and a-la-carte seminars offered and/or finding instructors for them, and keeping up-to-date with the latest research and best practices in the science communication community. Permanent staff would also be responsible for assessing the success of the program: examining whether students are achieving the learning objectives of the training in the short term, whether the program has a positive impact on their communication efforts in the long term, and whether CMU-trained scientists are having an impact on the public discourse on science.

Student collaborators would help maintain the vibrancy of a grassroots effort. They would cultivate an active PCR social community, organize practice and outreach opportunities, and ensure that the long-term vision of the PCR center reflects student needs on campus. This is similar to the role played by the Eberly Center graduate teaching fellows.

Required Resources

To establish such a such a public communication center at CMU, a number of different types of resources would be required:

Financial resources

- Salaries for 1.5 2 full-time staff, or its equivalent in part-time positions.
- Small stipends for 1-3 student positions. Alternatively, an arrangement could be made with individual departments under which students volunteering for PCR could be exempt of departmental duties such as TAing.
- External speaker expenses, including honorarium fees and travel expenses.
- Advertising and logistical costs.

N.B. These estimates are guided by our own experience with PCR, as well as the structure of the Stony Brook Center for Communicating Science (CCS),⁶ one of the few public communication centers in the country. The CCS employs three fulltime staff, as well as additional faculty to teach its communication courses. Their programming is similar to what we propose, so they represent a good guideline for resource allocation.

Space resources

This would include office space for the center staff and classroom space for the seminars, workshops, and classes. While we recognize space is a premium at CMU, office space for such a center could be anywhere on campus, and would only require a small physical footprint.

Administrative support

Support would be needed to identify funding sources, recruit staff and instructors, navigate the administrative and logistic requirements of establishing such a center, and advertising the center at launch.

References

⁶ http://www.centerforcommunicatingscience.org/

¹ Importance of the Lay Press in the Transmission of Medical Knowledge to the Scientific Community David P. Phillips, Ph.D., Elliot J. Kanter, M.L.S., M.A., Bridget Bednarczyk, B.A., and Patricia L. Tastad N Engl J Med 1991; 325:1180-1183October 17, 1991DOI: 10.1056/NEJM199110173251620

² "Diffusion of News About Research," Science Communication, Vincent Kiernan. Science Communication September 2003 25: 3-13. DOI: 10.1177/1075547003255297

³ Historical Trends in Federal R&D Spending (2014) Patrick J. Clemins . American Association for the Advancement of Science. http://www.aaas.org/sites/default/files/migrate/uploads/14pch02.pdf

⁴ http://www.nsf.gov/statistics/seind12/c3/tt03-20.htm

⁵ Frank, Adam. "Welcome to the Age of Denial." *The New York Times*. August 21, 2013: A27. Available online at http://www.nytimes.com/2013/08/22/opinion/welcome-to-the-age-of-denial.html



[9 months] Finalize curriculum: The staff works with the core team to concretize the center's educational program: finalizes the curriculum; creates courses, seminars and workshops; and finds appropriate instructors. In parallel, the staff also creates a plan for evaluating the effectiveness of the center's programming.

[3 months] **Conclusions and future directions:** The core staff report the conclusions of their evaluation back to the board of trustees, discussing the successes and shortcomings of this first trial, and their recommended course of action. At this point, the program may be expanded to serve undergraduate students, postdocs, and faculty.

Appendix A: Learning objectives of a sтем public communication program

In order to move from common practice to best practice, we've looked to many disciplines. We found we had much to learn from improv theater, rhetoric, journalism, and design. After consulting the curricula of other successful communication programs, we converged on the following core learning objectives.

At the end of this program, participants should be able to:

Incorporate the following when communicating about science:

- the motivation behind the work why it is important, and why anyone should care
- specific and vivid examples, metaphors, and images
- an emotionally compelling story for the audience to connect to
- a communicative framing that resonates with the values of the audience
- depiction of both the scientific process and its product
- audience-appropriate language, level of detail, length, tone, and non-verbals

Talk to the media by:

- identifying what makes a story newsworthy
- researching the audience and journalist
- anticipating questions and preparing answers
- directing the conversation to their main points
- dynamically adapting their approach to the conversation and its scope

Speak compellingly about science by:

- opening with a strong attention-grabber
- structuring a talk around a few primary points, and highlighting that structure
- generating easily interpretable visuals to support or replace text
- modulating vocabulary, body language, tone, volume, and rate to convey meaning

Write clearly about science by:

- choosing the entities to focus the story on
- structuring writing to emphasize that focus
- providing motivation and context in the beginning
- making the logical progression of the story clear
- structuring sentences to emphasize a desired interpretation

Appendix B: PCR workshops so far

In our first two years, we worked with museum directors, professors, journalists, and other graduate students to create nine workshops. Some of these would work best as semester-long courses, others are fine as standalone events. We hope these sessions will continue to be iterated upon, and will be taught in the future by a mix of outside speakers and a small group of dedicated staff who can provide consistent high quality:

So You Want to Be a Science Communicator?

Explaining science to the general public is not a matter of dumbing it down; it is a greater challenge to reach someone when you don't share a common background. In this workshop, we cover fundamentals: how to adapt to your audience's background, untangle their misconceptions, and explain complexity without being complicated.

Telling Science Stories

How do you make scientific ideas compelling? Even if your message is true and important, it's hard to reach a general audience with facts alone. Stories are memorable – stories have the power to captivate and inspire high school students, busy parents, and members of Congress. In this workshop with professional science journalists we learned and practiced how to compose a narrative about discovery.

Why are Facts Not Enough?

When we talk about science, we often assume that people are simply misinformed; if we could just explain the facts clearly, then everyone would think the way we do. Unfortunately, that's not how science understanding works. Research consistently shows that giving people more information does not persuade them – it polarizes them, depending on how that information threatens or affirms their values and group identity. By the end of this workshop, attendees learn to identify the values of four archetypal world-views, know which ones they fall into, and develop strategies for how to reach everyone else.

The Art of Argument

Great communicators know that communication is not merely articulating ideas; other factors affect audiences as much as the ideas themselves. Any time we communicate, we're also signaling who we are, how to feel, and how to think about something – three factors that block your credibility when mishandled. In this lively interactive workshop, we draw on the 2,500-year tradition of rhetoric to build a simple toolkit you can use to evolve your spoken and written information into great persuasion.

Communicating Science with Theatre Techniques

Theatre games aren't just for acting. They teach us how to stay authentic and personal when we're on stage, and how to talk to an audience of strangers the way we talk with our friends. Theatre techniques are what separates science lecturers from science communicators. This workshop is designed to help scientists fearlessly reveal the person engaged in the research and the energy that brought them to their work – without reducing the importance of evidence. Participants learn to use improvisation techniques to discover a sense of spontaneity, immediacy and collective communication.

Talking to the Media

Television, newspaper, radio and podcasts are key channels to explain why your work matters. Sitting down for an interview is a powerful opportunity to advocate for your field, correct misconceptions, and put a personal face to science. Interviewing requires more than just distilling your message into soundbites: you also have to improvise, tell a story that's personal and emotional, and all while under pressure. Anybody who does this well had to train for it. In this workshop with public relations experts, we cover how to get journalists interested in your work, how to prepare for media interviews, and analyze examples of good and bad interviews. This session includes a free booklet by Chriss Swaney, the culmination of a decade of material culled from media boot camps.

Interview Workshop

In our Talking to the Media seminar, we covered the basics of talking to the media. Learning about it is one thing, but actually doing it is another. How do you perform in front of a camera? Attendees find out at our interview workshops! We run a short 5-10 minute video interview with each student about their work, give them

feedback, and send them a copy of the footage to take home.

Planning and Delivering a 3-Minute Thesis

The Three Minute Thesis competition at CMU for the first time in 2014, presents the perfect opportunity to hone your science communication skills. Participants are required to "present a compelling oration on their thesis and its significance in just three minutes, in language appropriate to a non-specialist audience." In this session, we workshop all the steps of crafting a winning 3MT talk: distilling the core ideas, conveying them clearly and vividly, and planning and delivering the talk itself. Whether or not they are competing in 3MT, participants walk away with the tools they need to build a compelling, accessible talk.

Scientific Writing: Beyond Tips & Tricks

In order to write clearly, we must understand how we read. In this workshop, we learn how to align with readers' expectations with Judy Swan, world-famous science writer and 2013 TEDxCMU speaker.

Social Media for Science

It's easy to spend hours reading blogs, Twitter, and Tumblr. That can seem like a waste of time, but another view is that social media is compelling, and therefore a powerful tool to reach laypeople, journalists, and even other scientists. This handson workshop with Scientific American blogger @Scicurious explores how to write online in a way that's effective, productive, and worthwhile.

Appendix C: A review of science communication programs for graduate students

In Section 2, we were able to provide only very brief summaries of existing communication training programs outside of CMU. Below we include more details on the activities of each course and student seminar program mentioned:

University Courses

Stony Brook University's Alan Alda Center for Communicating Science (CCS), in collaboration with the university's School of Journalism, offers seven month-long courses and one full-semester course to Ph.D. and Master's students in the sciences. Modules include Improvisation for Scientists, Distilling your Message, and Writing to be Understood. The Center also offers a certificate specifically in health communications.

George Mason University offers eleven full-length, graduate-level courses on wide-ranging topics in science communication. The courses can be taken as part of the one-year Science Communication Graduate Certificate, which is geared toward both professional scientists and professional communicators.

Cornell University offers an annual, weekend-long Science Communication Workshop to graduate students in the sciences. The hands-on workshop is taught by Bruce Lewenstein, a well-known scholar of science communication.

The University of Washington offers a series of three "Science Communication Clinics," each of them a 4-week course. The clinics are taught by the staff of the COMPASS organization, which helps connect scientists to policymakers and the media.

Northwestern University offers a comprehensive, full-semester science communication course called Ready.Set.Go.

Several other universities offer less comprehensive or less well-established trainings: UC Davis offers a full-semester course entitled "Translating Research Beyond Academia"; the University of New Hampshire includes public outreach components in its graduate-level Scientific Communication course; Portland State University offers a graduate-level course entitled "Selling Your Science" (required for Ph.D. students in Environmental Sciences and Resources); and Pace University offers a course specifically on Environmental Science Communication.

Student Organizations

ENGAGE is a well-established, student-led effort at the University of Washington that aims to provide both training and practice in communication with non-specialists. Previously trained students teach an annual course for graduate students on such themes as storytelling, audience analysis, and public speaking. Each student in the course then gives a public talk on their research at the Seattle Town Hall. The program is advised by staff members of COM-PASS.

The Scientists with Stories project (SwS) is a collaboration between students at Duke University and The University of North Carolina at Chapel Hill. The group primarily runs workshops in multimedia communication skills, particularly documentary filmmaking, for marine sciences students. The works produced by participants are then distributed to local science education programs as outreach materials.

The ComSciCon workshop is organized primarily by graduate students from Harvard and MIT, with help from others around the country. The workshop brings together 50 graduate students in STEM from around the country to learn from panels of science communication experts. Attendees, with help from each other and the panelists, also produce original written works for publication in non-technical venues.

The Broader Impacts Group (BIG), a student group at MIT and Woods Hole Oceanographic Institution, aims to connect graduate students with "opportunities, activities and resources related to sharing science." The group invites speakers in for workshops and lectures, as well as arranging opportunities for graduate students to participate in outreach activities (e.g., the Cambridge Science Festival).

Communication Opportunities for Graduate Students

A primary goal of all these forms of training, of course, is to engage researchers in actual communication efforts. Many institutions do indeed boast organizations that provide sustained opportunities to interact directly with members of the general public. Examples at institutions other than CMU include Harvard's Science in the News, which organizes public talks and a science newsletter, and the many NSFsponsored GK-12 programs, which partners STEM graduate students with K-12 teachers.

Of particular note are several competitions that encourage graduate students (and sometimes others as well) to produce compelling works of science communication:

- NASA runs the U.S. division of Fame-Lab, a competition in which early-career scientists deliver three-minute science-themed presentations for non-specialist audiences.
- Many universities host **3-Minute Thesis** competitions (including CMU, as of this year).
- The Alan Alda Center for Communicating Science runs an annual "Flame Challenge," in which participants submit videos explaining a complex scientific topic at a level an eleven-year-old could understand.

Some universities even have dedicated science outreach offices, which (among their other roles) coordinate public outreach activities for university researchers to participate in. Schools with such centers include Stanford University, The University of Missouri, and Vanderbilt University. The University of Missouri's center also offers a graduate certificate in science outreach.

Professional Training Programs

Among the organizations offering professional training sessions are:

- The National Science Foundation (NSF), whose free "Becoming the Messenger" workshops have been attended by thousands of scientists around the country.
- COMPASS, an organization devoted to connecting scientists with policymakers and the media, which provides group training sessions and personalized coaching upon request.
- Stony Brook University's Alan Alda Center for Communicating Science, which runs compressed versions of its courses as workshops upon request.
- The American Association for the Advancement of Science (AAAS), which offers tailored public communication workshops upon request.

- The American Geophysical Union, which includes science communication workshops in its annual meetings.
- The Union of Concerned Scientists, which regularly hosts beginner- and intermediate-level webinars on science communication.
- NASA's FameLab competition, described further below, includes a communications workshop for competitors in each regional heat.
- The Pacific Science Center, which offers a science communication fellowship, culminating in a communication certificate.
- SciFund, an organization that connects scientists to outreach activities, which offered a free, month-long MOOC on science outreach in 2013.

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Jesse believes firmly in the need for scientific and technological literacy in modern society, and is thrilled to be working toward that vision. He is also easily distracted by birds.

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Before coming to CMU, Adona studied Computer Science in Cambridge, UK, where she worked on making programming languages for data analysis more accessible to non-computer scientists, and co-designed medical software for low-resource field hospitals in disaster areas.

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To watch past lectures and learn more about PCR events, check out our website:

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We tweet @PCRcmu and write articles on ScienceNonFiction.org