Can we train scientists to communicate effectively with the public?

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1 Goals and Objectives

The ability of scientists to effectively communicate with the public is imperative to our society. There exist few programs designed to provide scientists with the corresponding training, however, and those that exist tend to target professional scientists already established in their careers (e.g. [1, 2]). I propose to study the effects of training future scientists in public science communication much earlier in their career: at the undergraduate and early-graduate level.

Research questions:

1. Is integrating a small amount of written science communication training into existing science classes for majors sufficient to produce measurable improvement in students’ written public science communication skills?

2. Is there an optimal time in the undergraduate/early-graduate career to provide this training?

This research project aims to identify whether integrating a small amount of science communication training into pre-existing science classes is an effective way of training future scientists to communicate with the general public, or if other, more intensive training methods (such as dedicated courses and workshops) are necessary to teach these skills.

A positive outcome from this research will pave the way for immediate integration of science communication techniques into existing science courses, with little inconvenience to the faculty teaching the courses. A negative outcome will help to identify the specific barriers to this form of science communication training so that other methods can be considered.

2 Motivation and Previous Work

Though the role of public science communicator has traditionally belonged to journalists and specialists, there has been a trend in the last few decades calling for scientists to learn to communicate with the public directly [3, 4]. Scientists tend to agree that they have a moral obligation to the public: in a study of nearly 1700 scientists performed in 2000, 84% agreed they had a duty to communicate their research findings to the public, and a surprising 69% felt that they themselves should have the main responsibility for that communication [5].

In spite of this mindset, little training in public communication is currently conducted for scientists; a study commissioned by the Royal Society in 2006, for instance, shows that out of a sample of nearly 1500 professional scientists, 73% had never received any training in communicating science to the non-specialist public. Of those who reported having received training, most were only trained in the specific case of interacting with the press [6].

There are quite a few arguments in favor of ensuring that scientists are properly trained to communicate with the public, many of which center around scientists’ moral responsibility to convey the results and impact of their research to the public. Examples abound of the dangerous consequences that can arise when scientists fail to effectively communicate, from the public perception of vaccines [7] and climate change [8], to the criminal trial and sentencing of scientists in the wake of the deadly 2009 L’Aquila earthquake in Italy [9]. There is also personal benefit to scientists who learn to communicate effectively: continued funding is often dependent upon the public — and policy makers — being convinced of the worth of scientists’ research. This message is particularly clear today as we see the impact of the recent US government budget cuts to science funding.

As mentioned before, there are few communication training opportunities for scientists currently, and many of the programs that exist target scientists already established professionally. Furthermore, there appears to be
very little analysis of existing science communication training programs: none of the programs have performed any systemic evaluation of their courses’ learning outcomes (as reported in [10], hereafter BL13), and there are no studies on when in a scientist’s career is the best time for this training.

Very recently, Baram-Tsabari & Lewenstein 2013 (BL13) developed the first instrument for quantitatively measuring written skills in public communication of science. In the study I propose here, this tool will be used to meaningfully quantify the “measurable improvement” referred to in my second research question, within the novel context of examining the training of very-early-career scientists in written public communication skills.

This study focuses on written skills, rather than oral, for three reasons. First, there is evidence that the public still receives much of its science knowledge in written form, coming from the internet. According to a study by the Pew Research Center in 2006, 87% of online users have used the internet to carry out research on a scientific topic or concept, and 40 million adults use the internet as their primary source of news and information about science [11]. Second, much of the planned written communication training (such as minimization of jargon, use of analogies, etc.) can be practically applied to oral communication as well. And third, focusing on written skills allows analysis of larger samples without the need to record and transcribe oral responses — or to take into account more subtle factors such as tone or body language.

3 Theoretical Framework

3.1 Communication Theory

Science communication is typically based on either the deficit model or the dialog model. The primary approach used by scientists is the deficit model, which attributes public skepticism or negative views of science to a lack of understanding [12, 13]. In this model, the flow of information goes only in one direction — from the scientist to the public — and is intended to improve the public’s level of understanding [14]. More recently, the deficit model has fallen out of favor among science communicators, and there has been a push for use of the dialog model [2]. In this model, a two-way interaction occurs between the scientist and the public, and learning happens through the examination of experience via conversation [15].

The communication training provided in the proposed study will be designed within the framework of both models. Because the study focuses on written communication, the flow of information from the students to their intended audience will necessarily be one-directional, consistent with the deficit model. Nonetheless, emphasis in the training will be on eliciting reactions focusing on experiences, as in the dialog model.

3.2 Learning Theory

The writing techniques needed to elicit those reactions also require working within a specific learning framework: constructivism, the idea that people don’t learn in a vacuum. According to constructivism, all new knowledge is built upon the foundation of knowledge and experiences that the individual already has, and the new knowledge is then either fit into that context or rejected [17].

The training provided to students in the proposed study will use this theory to establish effective strategies for communicating with the non-specialist public, such as demonstrating relevance of the scientific topic, or using analogies that will resonate with previous experiences of the audience.

3.3 Definitions

In order to measure whether training helps students become more effective science communicators, we must first define “effective science communication.” I will be assessing the students’ writing samples using the instrument developed by BL13 (see §5.1). Thus, my operational definition for “effective science communication” is that which BL13 created, based on an extensive review of the literature. Their categories are shown below:
Clarity | Use appropriate language, address, readability, use basic explanations as appropriate, avoid jargon, acknowledge prior knowledge
---|---
Content | Select appropriate content: engaging, interesting, relevant to particular audience. Include scientific information, as well as nature of science, scientific method, implications
Knowledge Organization | Organize presentation well, using good pedagogical and communication techniques: main theme, framing, scaffolding, repetition
Style | Use style aspects creatively: humor, emotions, anecdotes, local references
Analogy | Develop analogic strategies for explaining complex topics
Narrative | Use complex narrative tools as appropriate, such as character development, conflict, and resolution
Dialogue | Acknowledge and show respect to multiple world views

### 4 Methodology

#### 4.1 Participants

I will collect data from classes chosen within my home department in Fall 2013. Proposed courses are shown in the table below; classes were selected to represent a broad range of student years.

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Title</th>
<th>Year</th>
<th>Student</th>
<th>Approx. Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 1030</td>
<td>Accelerated Intro to Astronomy 1</td>
<td>freshman</td>
<td>major</td>
<td>70</td>
</tr>
<tr>
<td>ASTR 2030</td>
<td>Black Holes</td>
<td>sophomore</td>
<td>major/non-major</td>
<td>200</td>
</tr>
<tr>
<td>ASTR 3710</td>
<td>Solar System Formation/Dynamics</td>
<td>junior/senior</td>
<td>major</td>
<td>50</td>
</tr>
<tr>
<td>ASTR 5120</td>
<td>Radiative and Dynamical Processes</td>
<td>first-year grad</td>
<td>major</td>
<td>10</td>
</tr>
</tbody>
</table>

Instructor approval has been obtained for all of the undergraduate courses. Approval from the instructor of the graduate course is pending, and alternate courses are available if the instructor chooses not to be involved.

It should be noted that ASTR 2030 will contain both majors and non-majors. This will allow me to conduct an additional test, tracking the difference in communication-skills learning gain and attitudes between majors and non-majors in this sample.

#### 4.2 Science Communication Training

The training will consist of four components:

1. In-class lecture/discussion
   For each course, a total of 30 minutes divided between two separate class periods will be spent discussing both the importance of public science communication and the specific elements of effective public science communication. For the sake of consistency in this study, those discussions will be led by me in a "guest lecture" environment. A detailed lesson plan will be composed from current best practices in science communication training. These best practices will be derived from previous studies (e.g. [15]). The lesson plan will be explicitly documented, both so that this experiment is repeatable and so that this training can be implemented by course instructors in the future.

2. Reading assignments
   Students will be assigned to read two or three articles popularizing recent scientific results topically related to their class (see [16] for an example source). This will demonstrate how other writers have distilled information from scientific research papers.
3. Writing assignments
Five homework assignments will be given during the semester, spaced every other week, in which students write two short (100-200 word) abstracts summarizing an assigned scientific subject, article, paper, etc. that I will select to be both topically related to their class and appropriate to the class level. The target audience for the first version is the students’ classmates/scientific peers, and the target audience for the second version is the general public. This two-version system is intended to help students identify differences in the type of language and styling appropriate at each level.

4. Peer-review
The students will peer-review each other’s homework writing samples. This is intended to give them feedback on their own writing, reinforce the lessons from the in-class lecture/discussion, and further expose them to examples of both good and bad writing.

5 Assessment

5.1 Efficacy of Training
The first of the five writing assignments will be given before the in-class lecture/discussion occurs, so that it can be used as a pre-training writing sample. The last of the five assignments will be used as a post-training writing sample, and the efficacy of the science communication training will then be established by comparing the two samples for each student. The samples will be evaluated independently by me and at least one additional education researcher using the written science communication assessment tool developed in BL13. This instrument quantitatively analyzes the consistency of a writing sample with the specific learning goals for written science communication described in §3.3 (see [10] for more details). Use of this instrument will allow us to assign a score to each writing sample and thus measure learning gain based on a pre/post score for each student.

5.2 Attitudes Toward Science Communication
Students’ attitudes toward science communication will be measured at the beginning and end of the semester in each class using a survey adapted from that commissioned by the Royal Society in 2006 to probe the attitudes of professional scientists toward public engagement [6]. A few sample survey questions are included below:

| Rate your level agreement (1= strongly agree, 5=strongly disagree) with the following statements. |
| Q1 | Scientists who engage in public communication are not well regarded by other scientists |
| Q2 | Scientists have a moral duty to communicate with the non-specialist public about the social and ethical implications of their research |
| Q3 | Communication with the non-specialist public is best done by trained professionals and journalists |

There are two goals of administering this survey to the students: first, to determine whether their attitudes toward science communication are dependent upon what stage of their academic career they are in, and second, to determine if these attitudes change after the students have had science communication training.

6 Proposed Timeline
This project will be begun in Summer 2013 and completed before my anticipated graduation date of May 2014.
### 7 Project Outcomes

#### 7.1 Further Personal Development

Science communication is a topic I feel very passionately about. I am currently co-organizing Communicating Science 2013, a several-day, 50-person workshop for graduate students, for which we received nearly 750 applications. It was this indication of the enormous demand for science communication training, coming from graduate students, that provided the inspiration for the project in this proposal.

In the immediate future, I intend to pursue this passion by applying for a postdoctoral position in science communication research as a next step in my career. Gaining experience and exposure with this project will increase my chances of being able to secure an appropriate postdoc opportunity.

Ultimately, I plan on a career in both education/public outreach and science communication training. I anticipate that both the results and the experience from this research project will allow me to be more effective in implementing science communication reform in my career. Furthermore, with this project I have the opportunity to build a background in education research while still under the guidance of my faculty advisor and the discipline-based education research community here at CU. Achieving a thorough grounding in education research practices, becoming familiar with the literature sources, making contacts within the field of education research, and becoming integrated into the education research community are all things that will benefit me regardless of where I go next.

#### 7.2 Support STEM Education Within the Home Department

The test subjects in this study, undergraduate and graduate astrophysics majors, will benefit from being involved in this project. The goals of our department include both education and professional development of students. If the science communication training is effective, then the students will have gained skills in clarity of expression that can be applied in nearly any chosen profession. And even if the training proves unsuccessful, previous research indicates that student writing assignments can be used to enhance learning of science content [18]. As such, I expect that this study will have a positive effect on participants in their courses, regardless of the study outcome.

#### 7.3 Benefit the CU Community

If it is shown that future scientists graduating from CU can be trained to be better science communicators using the methods employed in this study, then this is a tactic that can be immediately implemented in science classes university-wide. Increasing the ability of CU-educated scientists to communicate with the public will reflect positively on CU, as these scientists will be more effective at securing funding for their work and their studies will be more prominent and more favorably-viewed in the public eye.

### References