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Science Communication

ComSciCon-Triangle: Regional Science Communication Training for Graduate Students †

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The ability of scientists to effectively communicate their research, and scientific ideas in general, with a variety of audiences is critical in both academic and non-academic careers. There is currently a dearth of formal and informal science communication training opportunities for graduate students in science, technology, engineering, and mathematics (STEM) fields. This curriculum paper introduces ComSciCon-Triangle, a graduate student–organized science communication workshop for graduate students in STEM at research universities in the Raleigh-Durham, North Carolina, region. Started in 2015, this annual workshop aims to empower graduate students to be more engaged in communicating their research with the public as well as with fellow scientists. Each workshop consists of interactive panel discussions with invited science communicators (science writers, academics, filmmakers, etc.), informal networking opportunities with invited guests and other attendees, and hands-on sessions for improving oral and written communication skills. Analyzing pre- and post-survey data from all ComSciCon-Triangle attendees from 2015 to 2017, we find that workshop attendees feel significantly more confident in their ability to communicate scientific ideas with both the general public and with other scientists, and more confident submitting a written piece to a popular science publication or journal. We discuss how ComSciCon-Triangle serves as a model for local science communication workshops "for graduate students, organized by graduate students."

INTRODUCTION

Both the scientific community and the general public can benefit from improved communication of scientific concepts to broad audiences (1). Sustained communication efforts between scientists and the public can increase the public's trust in the sciences (2) and promote incorporation of science into policy decision-making (3). Science communication benefits scientists as well, as it expands writing and speaking skills that are integral to diverse career paths (3–5). As such, there is considerable interest amongst graduate students for science communication–related opportunities and resources. When the National Science Foundation Division of Graduate Education solicited ideas from graduate students on how to improve graduate education in 2013, nearly 40% of submissions identified the need for additional professional development opportunities, including training in collaboration and communication skills (6, 7).

Despite this interest, formal training for graduate students in science communication skills is not widely available (1). Existing training opportunities include those offered by COMPASS, which provides interactive workshops around the link between communication and leadership (8). The Alan Alda Center for Communicating Science also offers programs for MSc and PhD students in scientific disciplines, including a traveling workshop, in addition to online opportunities for scientists to practice explaining fundamental scientific concepts to the general public. Student organizations such as Harvard's Science in the News provide opportunities for graduate students to practice and receive peer-review of communication skills through blogging, public presentations, and events (9). A few graduate programs have integrated science communication training more formally. The Meat Science Program at the University of Illinois incorporates science communication opportunities with broad audiences into their graduate curriculum (10). Additionally, the Engage seminar course at the University of Washington allows students to practice storytelling and improvisational skills. These programs are not widely available and accessible and vary significantly in their content (7).

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We present a science communication workshop for graduate students called ComSciCon-Triangle that addresses this demand for communication training by providing a financially and geographically accessible model that can be easily adapted by organizers in regions across the country. ComSciCon-Triangle (https://comscicon.com/comscicon-triangle-2017-workshop) is a science communication workshop held annually for 50 graduate students in the North Carolina Research Triangle region. The workshop was founded by graduate-student alumni of the national Communicating Science workshop series held annually in Cambridge, Massachusetts, since 2013 (https://comscicon.com/). Colloquially known as ComSciCon (Communicating Science Conference), the national workshops are multi-day programs for STEM graduate students from universities across the country that emphasize training in science writing and multimedia communication through interactive discussions with professional communicators and hands-on practice sessions. While the national workshops provide talented graduate students with communication and professional development opportunities, fewer than 6% of the nearly 1,000 yearly applicants are admitted to attend the workshop through its competitive application process. Local workshops can more readily meet the demand of graduate students for science communication training. Started in 2015, ComSciCon-Triangle was the first local workshop modeled after the national Communicating Science workshop to be held outside of the Boston area.

In this work, we present the typical curriculum for ComSciCon-Triangle workshops and assess their efficacy in improving student confidence in communicating science with both scientific and general audiences, including submitting popular science pieces for publication in respected outlets.

Intended audience and prerequisite student knowledge

ComSciCon-Triangle is designed for students in STEM MSc and PhD programs and draws most of its attendees from Duke University, the University of North Carolina at Chapel Hill (UNC-CH), and North Carolina State University (NC State). Graduate school is the phase of a scientist's training when professional development and science communication training opportunities can have a powerful impact in their research and throughout their career (10). Graduate students have the technical expertise to interpret scholarly research at a high level but are also not far removed from earlier stages of their academic career. They are thus uniquely positioned to interact easily with both young audiences and non-scientifically trained adults, with the flexibility to pursue new initiatives. This workshop could certainly be adapted for upper-level undergraduate students who are actively engaged in research in their major field. Early opportunities for science communication training could provide undergraduate students with a better foundation in communication skills.

There is no prerequisite knowledge or formal training in science communication required for students to attend the workshop. Using existing relationships with various university offices and initiatives at Duke, UNC-CH, and NC State, applications for the workshop are advertised to graduate students in STEM disciplines primarily via departmental e-mail and social media.

Learning time

ComSciCon-Triangle typically runs for two full days on consecutive Saturdays. The total workshop time is approximately 14 hours. During the week between the two days of the workshop, participants are asked to write or produce a piece on a scientific topic of their choosing aimed at a broad audience. This piece is intended to be a first draft. In addition to writing their own piece, participants are expected to peer-review the drafts of three or four other participants on the second day of the workshop.

By partnering with various local and national publication outlets, we also offer attendees the opportunity to potentially publish their pieces. With the help of the workshop organizing committee, attendees continue to edit their pieces and develop pitches for their work to specific publication outlets. If they choose to pursue this opportunity, the time needed to complete their piece varies among different individuals and publication outlets.

Learning objectives

Upon completion of this workshop, participants will have

1. engaged in interactive, hands-on training from invited experts on ways to improve their written and oral science communication skills
2. received instruction and encouragement on how to take an active role in communicating their research and, more generally, scientific ideas with the public
3. received help facilitating the publication of their writing and/or other materials produced during the workshop.

The ComSciCon local workshops serve a purpose that is complementary to, but distinct from, the national ComSciCon workshops. The national workshop series has a strong focus on leadership and the formation of new, large-scale science communication initiatives. Local workshops, which serve smaller, regional sets of students, focus more on training in practical writing, verbal communication skills, and networking at a local/regional level.

PROCEDURE

Application process

Fifty attendees are selected for each workshop using a competitive application process. Our workshop gives participants the opportunity to receive feedback on their

own writing from local invited experts. The number of available experts and funding limit the size of our workshop to 50. This number of workshop participants can be adjusted based on available funding and the number of available expert reviewers. In addition to providing basic information such as optional demographic data, program of study, year in graduate school, etc., applicants are asked to provide written responses to the following questions in fewer than 750 characters:

1. Why do you want to attend the ComSciCon-Triangle workshop? How would attending help or influence your studies and your future career?
2. Writing sample prompt: A friend who is a professional in a very different field than yours is interested in your studies. They have asked what the most exciting research area, event, or other development is in your field today. Please write a response.
3. What is your previous experience in scientific communication to nonscientific audiences (outreach, blogs, policy, etc.)?

An example of an application can be found in Appendix 1. Each application is anonymized, reviewed, and scored independently by two members of the ComSciCon-Triangle organizing committee. Application scores are out of 10: Questions 1 and 2 above are each assigned a score of 0 to 4 and applications are given an overall impression score of 0 to 2. In their responses to question 1, applicants must demonstrate both clear enthusiasm for attending the workshop and the importance of communicating with a diverse set of audiences in their future career. For question 2, responses are scored based on whether the applicant clearly explains their research without the need for jargon, describes the broader impact/importance of their work, and uses engaging language.

Responses to question 3 are not given an explicit score, as previous formal science communication experience is not required for students to attend the workshop. The responses are, however, taken into account by reviewers when assigning the overall impression score. When evaluating applications, responses that demonstrate proper motivation and interest are highly favored. To compare the scores given by different reviewers, we standardize them: we convert the raw scores to normalized values from the distribution of scores for each reviewer characterized by mean and standard deviation. If the two independently normalized scores of an application differ by more than one point, a third reviewer scores the application. Applications are then ranked by the average of these normalized scores.

We accept the 12 highest-scoring applications from each supporting university (Duke, UNC-CH, and NC State), and fill the remaining 14 slots with the next highest-scoring applications from the pool of applicants. These selection criteria can be adjusted to accommodate different workshop sponsors and populations and can include selecting students from more or fewer universities and catering to the requests of different sponsors. Those who are not selected for the workshop are invited to apply to future workshops and are given a list of science communication resources they could explore on their own.

Description of workshop

While ComSciCon-Triangle workshops host a variety of guest speakers and interactive sessions, all of the workshops include the following: three to five interactive panel sessions with invited experts; one-minute non-technical research talks ("pop-talks") by all attendees; and a writing workshop ("write-a-thon") where attendees produce and receive feedback on original popular-science pieces. Each of these activities serves to facilitate the practice of different forms of communication as well as the discussion of related topics. While this workshop contains all three components, each activity could certainly be used and adapted individually as best serves the needs and resources of a given population.

Panel sessions. Panel sessions vary widely in their focus and have included traditional academics, film-makers, science journalists, and many other science communication professionals. Each iteration of the workshop has included different sets of panels, and adaptations should reflect topics that best fit the need of the served population. Prior to the workshop, participants are asked to submit questions for each panel. These questions allow the panel moderator to best guide the conversation. After an initial introduction of the discussion topic, each panelist introduces themselves and describes their background and interests. Panels then continue with a traditional question-and-answer format for one to one and a half hours. ComSciCon-Triangle panel sessions since 2015 have included the following:

- Multimedia and Non-Print Communication (2015). This panel featured speakers who communicate science through a variety of non-print outlets. Guests included a science comedian from the North Carolina Museum of Natural History and the NC State Director of Public Science.
- Writing and Editing Fundamentals (2016). In this hands-on session, two science communication professionals led participants through writing and editing exercises as they prepared their write-a-thon piece. Participants practiced paying careful attention to the use of scientific jargon, using descriptive imagery, and forming an engaging narrative.
- Science Policy and Communicating Science to Skeptical Audiences (2017). This panel was comprised of academic and non-academic professionals who spoke about how to address controversial topics with general audiences. Topics included understanding the background and values of an audience and engaging with audiences in familiar environments.

Pop-Talks. During the workshop, all attendees are required to give a one-minute talk in front of all of the attendees, speakers, and organizers. These elevator-pitch-style presentations must describe their graduate research or a scientific topic of interest to them and must be accessible to a general, non–scientifically literate audience. No visual aids are allowed. Each speaker is given live feedback from the audience using green cards that say "Clear" and orange cards that say "Jargon." Workshop attendees are instructed to use the cards liberally in order to let the speaker know which parts of the talk are particularly understandable or interesting and which terms or phrases are too technical. The wide array of scientific backgrounds of the attendees makes this live feedback particularly useful, since many graduate students only practice talking about their research in front of expert audiences.

Writing workshop. The final component of ComSciCon-Triangle is the writing workshop, colloquially called the write-a-thon. Prior to the first day of the workshop, attendees are asked to brainstorm ideas for a 500- to 800-word popular-science piece on a topic of their choosing (see the instructions in Appendix 2). During the first day of the workshop, attendees are randomly assigned to small working groups comprised of attendees from different scientific backgrounds. They are given time to discuss their ideas and receive peer feedback. In between the first and second days of the workshop, attendees are asked to write a rough draft of their piece to be reviewed by an "expert" reviewer. These expert reviewers are typically invited guest speakers at the workshop and other local science communication professionals invited to participate only in the write-a-thon portion of the workshop. All invited speakers and additional expert reviewers are offered a modest honorarium and are encouraged to stay for the duration of the workshop. ComSciCon-Triangle attendees have had write-a-thon pieces published or accepted for publication in outlets such as Hippo Reads, Natural History Magazine, and Scientific American Guest Blog. Additionally, we continue to work with attendees after the workshop to help them pitch and publish their work. A sample program, from the ComSciCon-Triangle 2017 workshop, can be found in Appendix 3.

DISCUSSION

Evidence of success

Attendees are asked to fill out surveys before and after attending the ComSciCon-Triangle workshop each year (Appendix 4). Adapted from the survey given each year by the national ComSciCon workshop (11), these surveys address previous training in science communication, confidence levels in science communication skills, and attitudes related to the state of science communication. Many of the questions addressing attitudes toward science communication were based on a survey developed by the Royal Society and administered to a group of nearly 1,500 research scientists at higher-education institutes (12). The University of North Carolina-Chapel Hill Institutional Review Board determined that the analyses of the results of these surveys do not constitute research on human subjects as defined under federal regulations (see 45 CFR 46.102 (d or f) and 21 CFR 56.102(c)(e)(l)) and do not require IRB approval.

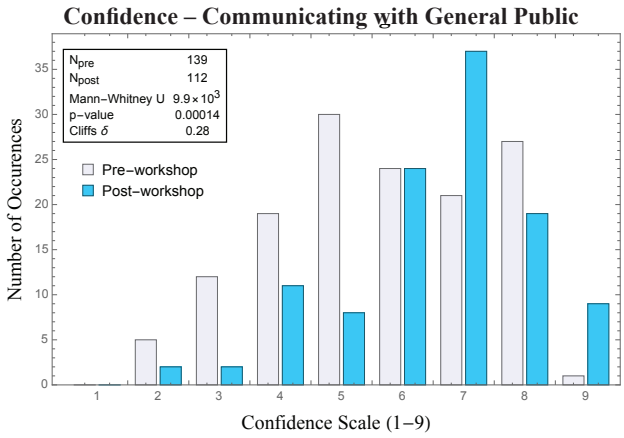
ComSciCon-Triangle aims to empower young scientists to better communicate with both scientific and nonscientific audiences. As such, we consider an increase in confidence levels related to science communication skills after attending the workshop evidence of success. Similar metrics have been used in the literature to assess the effectiveness of science communication courses (13). As part of the pre- and post-workshop surveys, attendees were asked to rank how confident they were communicating with the general public, communicating with other scientists, and submitting to a popular science outlet, each on a scale of 1 to 9 (1 = not at all confident; 9 = very confident).

We analyze the data using two methods. The first method uses the data aggregated from 2015, 2016, and 2017 to study the change in the distribution of answers across all ComSciCon-Triangle attendees. The second method studies the responses paired by attendee from the 2016 and 2017 workshops in order to understand changes in confidence at the individual level.

Method 1: Mann-Whitney *U*-test with unpaired, aggregated data. The distribution of self-reported confidence levels related to science communication of participants from all three workshops increased significantly (Fig. 1). The Mann-Whitney *U*-test is used to test the null hypothesis that a randomly selected posttest score is equally likely to be greater than or less than a randomly selected pretest score. In all three cases for attendee confidence—communicating with general audiences, communicating with scientists, and submitting to a popular science publication—the posttest results are significantly different from the pretest results. (The *p*-values were 0.00014, 0.00041, and 0.0000023, respectively. The Cliff's delta effect size (14), which ranges from -1 to 1 and measures the overlap of the distributions, with 0 indicating complete overlap, was found to be 0.28, 0.25, and 0.34, respectively. These also reflect a moderate increase in self-reported attendee confidence levels.)

Method 2: Linear mixed-effect model with paired data by individual. To consider individual changes in confidence levels, we used linear mixed models. These models included timing (pre- or post-workshop) and the year attended as fixed effects and the individual attendee as a random effect (15). Attending ComSciCon-Triangle significantly increased confidence levels of individual participants in communicating to all three audiences (communicating to the general public: $F_{1,67} = 23.6864$, $p < 0.0001$; communicating with other scientists: $F_{1,67} = 9.1324$, $p = 0.0036$; submitting to popular science outlet: $F_{1,67} = 12.2036$, $p = 0.0008$, Fig. 2).

A.



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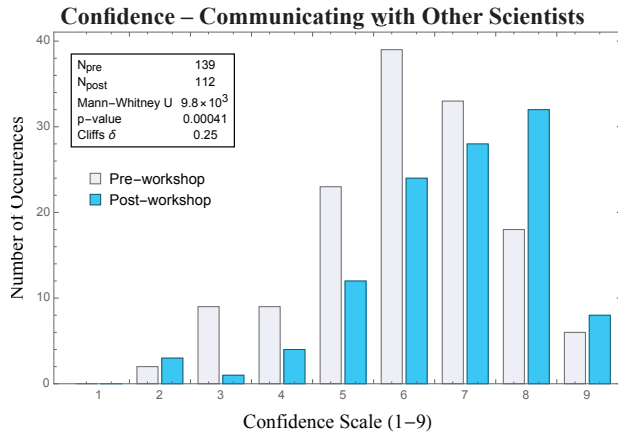

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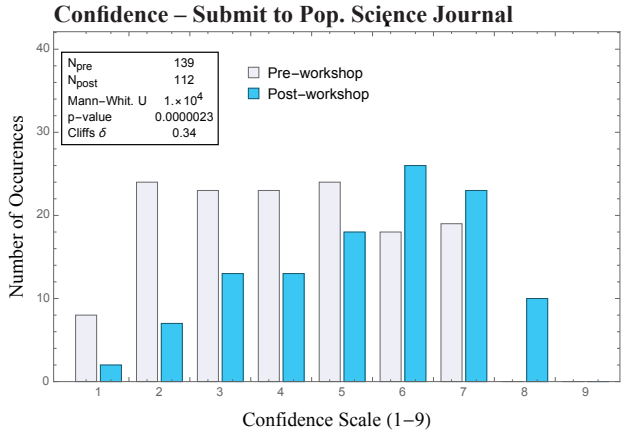

FIGURE 1. Confidence communicating with various audiences. Histograms showing the self-reported level of confidence (from 1 to 9, where 1 = "not at all confident" and 9 = "very confident") of attendees before and after attending and fully participating in a ComSciCon-Triangle workshop. Plots (A) and (B) show attendee confidence in communicating with the general public and scientifically trained audiences, respectively. Plot (C) shows the level of confidence attendees have with submitting a popular science piece to a journal or publication. Plots (A), (B), and (C) each have a p value of < 0.001, suggesting a significant improvement in attendee confidence in each case after participating in a ComSciCon-Triangle workshop. Exact p values are shown in the figures, which show aggregated response data from all three (2015, 2016, 2017) workshops.

There were some instances in which individual participants reported a lower confidence level in communicating to these audiences after attending the workshops. As participants filled out the pre- and post-workshop surveys up to two months apart and may not remember their original responses, this may in part be due to stochastic variation. These effects were not affected by year attended.

Strengths and weaknesses

ComSciCon-Triangle addresses an unmet need for science communication training for graduate students in STEM fields. A recent report from the National Academies of Sciences, Engineering, and Medicine states that the most effective approach for communicating science depends on communicator goals, which can range from simply sharing findings to increasing appreciation of science as a way of looking at the world (16). This workshop gives participants the opportunity to practice foundational skills necessary for any such goals.

One of the greatest strengths of ComSciCon-Triangle workshops is that they are run and organized entirely by graduate students specifically for graduate-student attendees. The organizers of the 2015 workshop had all attended the 2013 or 2014 national workshop and organizers of the 2016 and 2017 workshops were chosen (using an application process) from the previous year's ComSciCon-Triangle attendees. This formula ensures sustainable leadership teams for subsequent workshops while also bringing in new perspectives and ideas. Kuehne (1) suggested using formal graduate coursework to implement science communication training for graduate students. ComSciCon-Triangle could serve to augment such formal curricula, providing graduate students with a yearly conference that allows them to apply skills they have learned in the formal class setting, interact with students from other universities, and forge a strong culture of graduate students taking active roles in communicating their own research with diverse audiences. Additionally, workshops like ComSciCon-Triangle that are run by graduate students can be easily implemented with a wide range of funding levels and can be more readily implemented than changes to a university program's graduate curriculum.

As the longest-running local ComSciCon workshop and the first held outside of Cambridge, Massachusetts, ComSciCon-Triangle demonstrates that the national workshop model for science communication training workshops can be extended to a different local/regional university community. The relatively simple structure of ComSciCon workshops, combined with the effective sharing of key planning resources and infrastructure, has allowed a number of recurring local workshops to be established across the country since 2015. Five national ComSciCon workshops have now been held in Cambridge, and eight local workshops have been established in various regions including Chicago, San Diego, Houston, and Seattle.

ComSciCon-Triangle workshops also provide networking opportunities for attendees—to meet, to create new communication and outreach initiatives, and to recruit for existing projects. Examples include a writing and peer-review group started at the 2016 workshop and the recruitment of writers to an existing blog platform run by one of the workshop participants. Each year since 2016, the workshops have featured a session where attendees share information about their existing science communication projects and pitch new ideas to interested attendees. These one-minute pop-talks provide an excellent forum for inter-institutional collaborations. In future studies, we are interested in tracking the impact that ComSciCon-Triangle has on expanding existing communication initiatives and/or helping to kick-start new projects.

One of the limitations of ComSciCon-Triangle is that the event occurs only once per year, and cannot by definition provide continued training for students. However, several spin-off groups of ComSciCon-Triangle are being planned, including a writing club that meets monthly/bimonthly to encourage past participants to continue practicing communication skills.

An area in which the workshops could be improved is oral communication training. Pop-talks are given by each attendee and receive live feedback once during the course of the workshop. The format of the workshops could, in the future, offer chances for attendees to retool their pop-talks and give them again. While we did host a competitive second round of pop-talks by attendees at the North Carolina Museum of Natural Sciences in 2015, we want to dedicate additional workshop time to oral communication training, in various short and long forms, at future ComSciCon-Triangle workshops.

Finally, the majority of ComSciCon-Triangle attendees have been from the life sciences (Table 1). Future workshops will pay special attention to targeting departments such as physics, mathematics, chemistry, and computer science to increase diversity of fields.

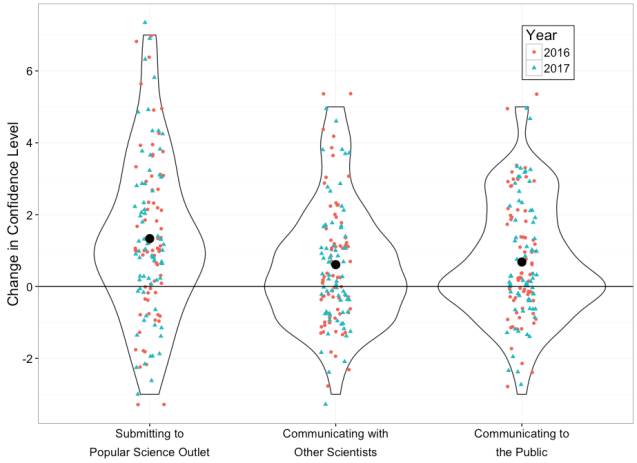

FIGURE 2. Confidence communicating with various audiences. Changes in confidence levels are shown for communicating to three audiences: popular science outlets, other scientists, and the public. Before and after attending and fully participating in a ComSciCon-Triangle workshop, participants self-reported level of confidence (from 1 to 9 in each category, where 1 = "not at all confident" and 9 = "very confident"). Each point represents the change in confidence level for an individual attendee after attending ComSciCon-Triangle. Red circles show data from participants in the 2016 workshop and blue triangles show data from participants in the 2017 workshop. The violin plots illustrate kernel probability density. The width of the outlines represent the proportion of data located there. Areas in which the width is wider indicates that more points fall in that range; for example, the highest proportion of data for "Submitting to Popular Science Outlet" is located at approximately a change in confidence level of 1.

CONCLUSIONS

We introduced ComSciCon-Triangle, a science communication workshop for graduate students, at universities in the North Carolina Research Triangle region. Organized entirely by graduate students, these workshops offer STEM MSc and PhD students the opportunity to improve their written and oral science communication skills and to network with other talented young science communicators from a variety of STEM fields. Using pre- and post-workshop survey data, we demonstrate that ComSciCon-Triangle workshops improved the confidence of attendees in their ability to communicate science with the public and with other scientists, as well as their confidence in submitting written pieces to various popular science publications and journals. ComSciCon-Triangle serves as a model for how science communication workshops such as ComSciCon, targeted specifically at graduate students, can be implemented entirely by young scientists at a formative stage in their scientific training. Future studies of the efficacy and impact of these workshops (currently in progress) will include a

TABLE 1.
Fields of study of attendees at the 2015, 2016, and 2017 workshops.

Field of Study	Number of Participants (*N* = 139)
Biology	75
Social Science	14
Geology/Earth Science	11
Chemistry	7
Physics	6
Mathematics	5
Engineering – Other	5
Engineering – Civil	4
Engineering – Biological	4
Astronomy/Astrophysics	4
Materials Science	2
Engineering – Chemical	2

longitudinal study of attendees who have participated in either the national or local workshops since 2013.

SUPPLEMENTAL MATERIALS

Appendix 1: ComSciCon-Triangle application (sample)
Appendix 2: Write-a-thon instructions
Appendix 3: Example of ComSciCon-Triangle program (2015)
Appendix 4: ComSciCon-Triangle pre- and post-workshop survey questions

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