UMASS DONAHUE INSTITUTE • RESEARCH & EVALUATION GROUP

Center for High-rate Nanomanufacturing

Research Experience for Undergraduates

Evaluation of the Summer 2009 Program

December 2009

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Introduction

Funded by the National Science Foundation (NSF), the Center for High-rate Nanomanufacturing (CHN) brings together three universities with unique strengths in nanoscience and nanomanufacturing: the University of Massachusetts, Lowell (UML); Northeastern University, Boston (NEU); and the University of New Hampshire, Durham (UNH). The University of Massachusetts Donahue Institute (UMDI) is conducting the five-year evaluation of CHN's education and outreach activities. The evaluation uses multiple sources of evidence to analyze project processes and outcomes. Using quantitative and qualitative methods, UMDI is documenting innovative and promising practices and exploring program outcomes for faculty members, undergraduate and graduate students, and targeted K-12 students and teachers. Research areas include the influence of CHN's activities on the following:

- Increasing interactions among faculty and students from the three participating institutions;
- Increasing awareness of the importance of science and technology;
- Motivating students, particularly women and underrepresented minorities, to become interested in and better prepared for STEM (science, technology, engineering, and mathematics) careers; and
- Preparing students for careers in research and manufacturing related to nanotechnology.

The evaluation plan is structured to meet the following objectives:

- Measure the program's effectiveness in achieving its stated goals and objectives;
- Provide timely and meaningful formative feedback on program implementation and quality; and
- Support documentation of the project model and its outcomes for future dissemination and replication.

This report represents one component of the larger evaluation. It provides information on the CHN Research Experience for Undergraduates (REU) which occurred during the summer of 2009. Undergraduates work with professors, postdoctoral fellows, and graduate students during the 10-week program to conduct nanomanufacturing-related research in laboratories at UML, UNH, and NEU. Research projects included a literature review of relevant material, informal presentations, formal PowerPoint presentations, and hands-on activities and research related to a topic in nanoscience or nanomanufacturing. REU students also receive training in ethical issues in nanomanufacturing and participate in workshops at the Boston Museum of Science focused on improving their science communication skills. The report is organized into the following sections:

- **Method** – Provides a narrative description of the report, including a description of the measures, response rates, and data analyses.

- **Results** – Reports research findings in the following categories: Demographics/Background, Program Impacts, Student Impressions, and Science Communication Workshops.

- **Conclusion –** Provides a brief summary of main findings.

- **Appendices –** Includes the web-based survey, focus group questions, Science Communication Workshop key stakeholder interviews, and Science Communication Workshop surveys.

Method

The evaluation of the 2009 REU program included the following four data sources:

1. A web-based survey that participants completed at the end of the program.
2. Focus groups conducted with program participants.
3. Surveys conducted before and after each of two Science Communication Workshop days.
4. Phone interviews with key REU stakeholders about the Science Communication Workshops.

At the end of the REU program, participants were asked to complete a web-based survey and a focus group. The survey solicited demographic information about program participants, and both measures asked students about their impressions of the program and their suggestions for program improvement. The survey measure and focus group questions included both fixed-response and open-ended items and are included in Appendix A and Appendix B. Focus groups were conducted with students from UML and NEU, but not with students from UNH due to scheduling constraints. To obtain comparable information from the UNH students, additional open-ended items were added to their version of the web-based survey. Questions and rating scales from the web-based survey and focus groups were designed by the evaluators and reviewed by the CHN Program Coordinator. Changes were then made through an iterative process of drafts and feedback.

During the final week of the program the 23 REU students (11 from UML, seven from NEU, and five from UNH) each received an email with a link to the survey on the SurveyMonkey website and assurance that there responses were confidential. During their focus group sessions, students were reminded about completing the survey, and those who did not complete the survey received email reminders one and two weeks later. All but one student responded to the survey, and all but one student participated in a focus group.

Two sets of measures were devoted specifically to the Science Communication Workshops at the Museum of Science. First, UMDI interviewed key stakeholders in the REU program by phone, soliciting their feedback about the Science Communication Workshops (Appendix C). Second, REU students completed surveys before and after each of the two workshops (Appendix D). Both sets of measures were developed by the director of the workshops at the Museum of Science in collaboration with UMDI.

Fixed response items were analyzed using standard quantitative and descriptive techniques, assisted by PASW 18 and Microsoft Excel. Open-ended responses were analyzed using a standard qualitative technique that involved multiple readings of the data and the assignment of themes around recurring ideas. Once themes were identified, each response was coded by its appropriate theme, and patterns that emerged are described in the report.

Results

This section provides an overview of the 2009 Research Experience for Undergraduates program, including participant demographics and background, program impacts, student impressions of the REU program, and a section devoted to the Science Communication Workshops. The total number of valid responses for each question may vary because some individuals did not respond. Response percentages exceed 100% for some questions that permitted multiple responses per respondent.

Demographics / Background

Demographic information is reported based on students' responses to the Web-based survey (N=22). Sixty-eight percent were male, and 32% were female. Seventy seven percent were Caucasian/White (N=17), 9% were Hispanic/Latino (N=2), 9% were African American/Black (N=2), and 5% were Asian (N=1). One student reported having a disability.

Eleven students (50%) reported that they were completing their REU at UML, six (27%) at NEU, and five (23%) at UNH. Not all students were enrolled at the university where they completed their REU. Of the 22 respondents, eight (36%) were enrolled at UML, four (18%) at UNH, and two (9%) at the University of Puerto Rico. One student attended each of City College of New York, Clarkson University, INSA (Rennes, France), Middlesex Community College, NEU, Pennsylvania State University, Tufts University, and UMass Boston. Eighteen percent had just completed their freshman year, 36% had completed their sophomore year, and 46% had finished their junior year.

Students reported that they had learned about the REU program through their academic advisors (50%), another faculty member (32%), or a friend (14%). Three students learned about the REU program through the CHN website, one by attending a workshop, and one was invited to attend by Dr. Chen.

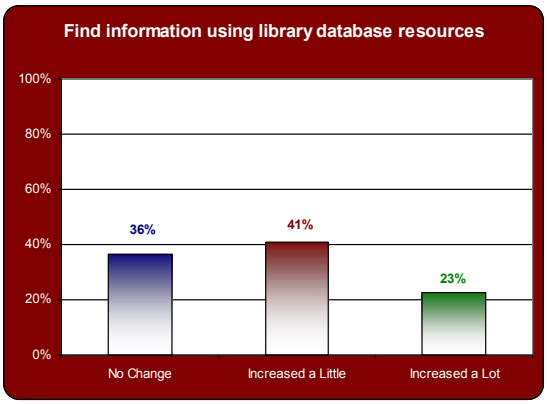
Academic majors of REU students were mainly in engineering, physics, chemistry, and biotechnology. For most students, post-graduation plans included graduate school or full-time employment in a STEM-related field. None planned to find full-time employment outside STEM fields or in the field of STEM education (see tables).

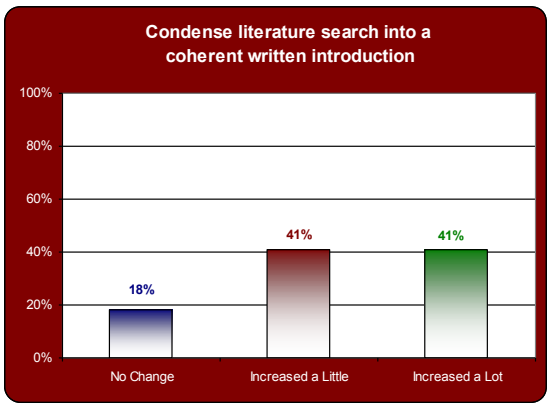
Academic Concentration	N	%
Mechanical Engineering	6	27%
Physics	4	18%
Chemical Engineering	3	14%
Chemistry	2	9%
Electrical Engineering	2	9%
Industrial Microbiology	2	9%
Plastics Engineering	2	9%
Biochemistry	1	5%
Math	1	5%
Materials Science and Nanotechnologies	1	5%
Philosophy	1	5%

What are your plans after graduation?	N	%
Pursue a Master's degree	12	55%
Pursue a Doctoral degree	9	41%
Find full-time employment related to STEM	9	41%
Find full-time employment not related to STEM	0	0%
Find full-time employment in STEM teaching or education	0	0%
Don't know	1	5%
Other	4	18%

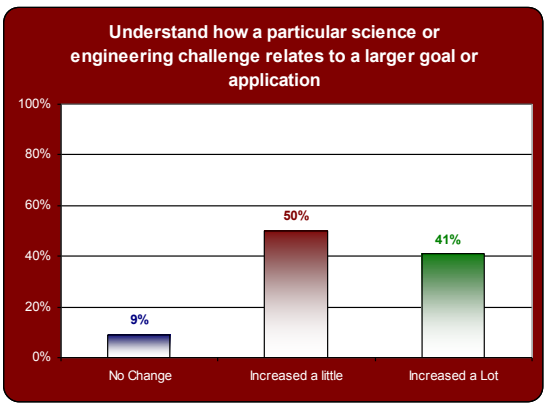
Program Impacts

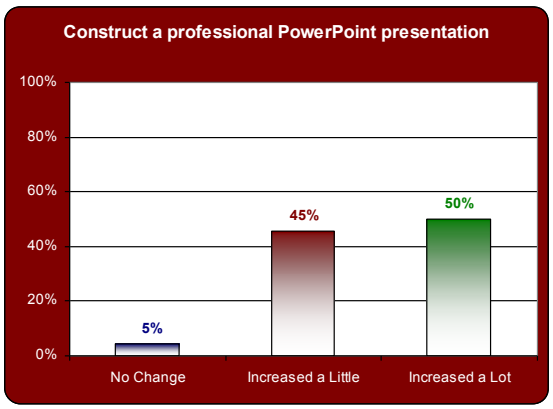
Participants were asked how their ability level in eight areas changed as a result of their participation in the REU program. Sixty-four percent reported that their ability to find information using library data resources had increased a lot or a little, and 82% reported that their ability to condense a literature search into a coherent written introduction increased a lot or a little.





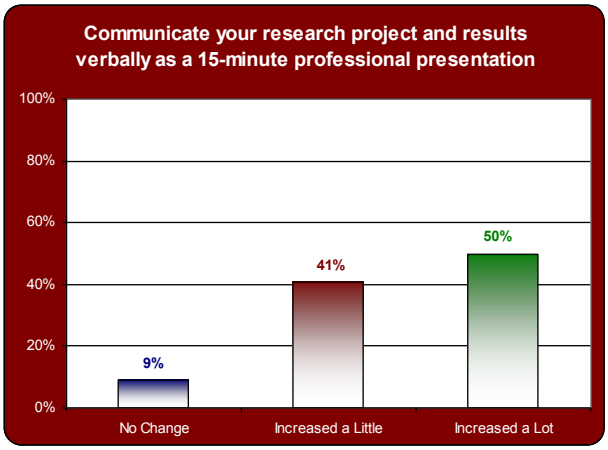
Ninety-one percent reported that their ability to understand how a particular science or engineering challenge relates to a larger goal or application increased a lot or a little, and 95% reported that that their ability to construct a professional PowerPoint presentation increased a lot or a little.

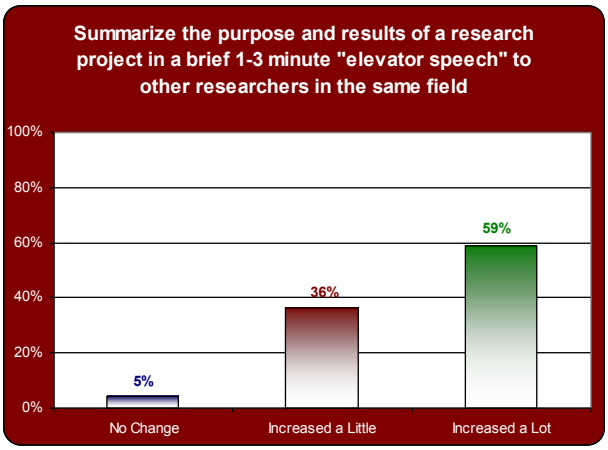


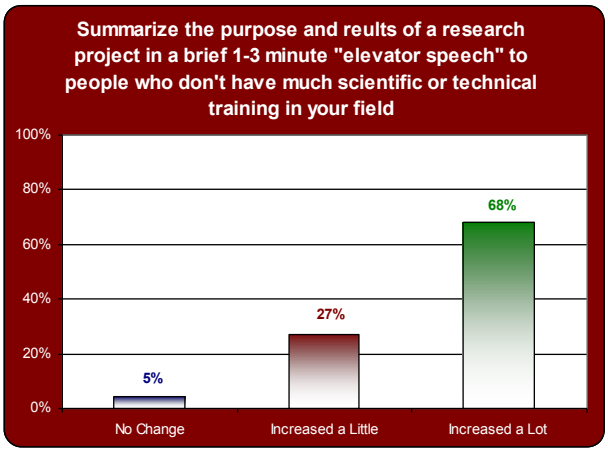


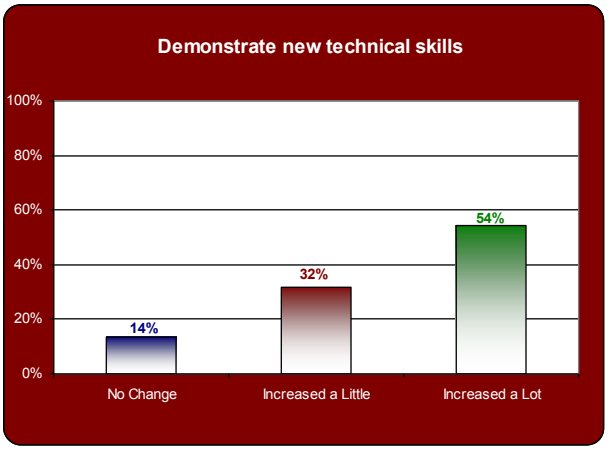
Ninety-one percent reported that their ability to communicate their research projects and results verbally as a 15-minute presentation increased a lot or a little, and 95% reported that their ability to summarize the purpose and results of a research project in a brief 1-3 minute "elevator speech" to other researchers in the same field and to nonscientific audiences increased a little or a lot. Eighty-six percent said that their

ability to demonstrate new technical skills increased a lot or a little as a result of their summer research experience.

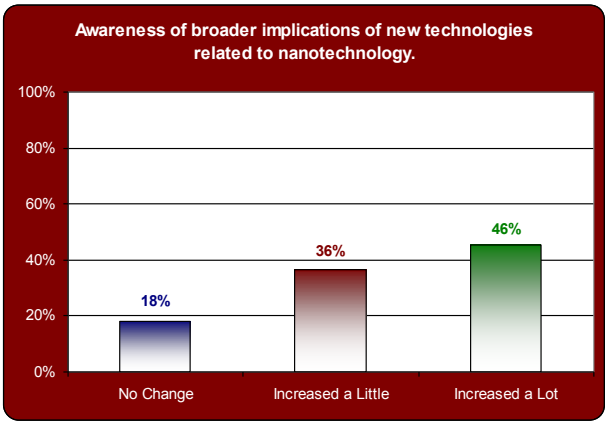


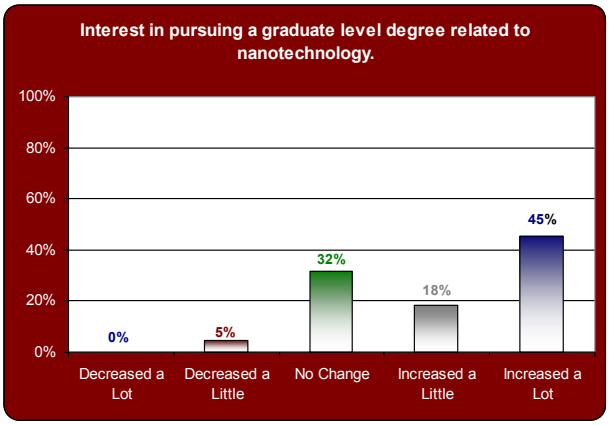




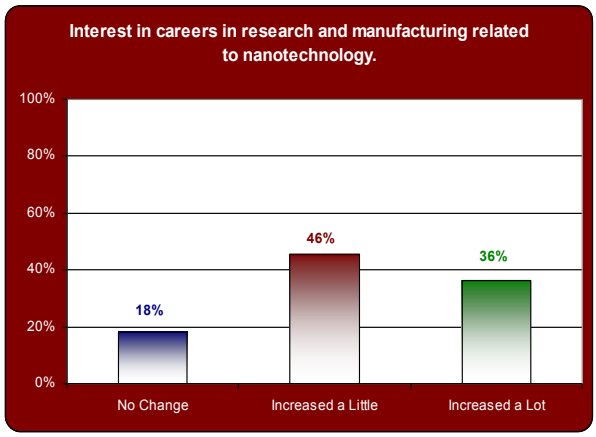


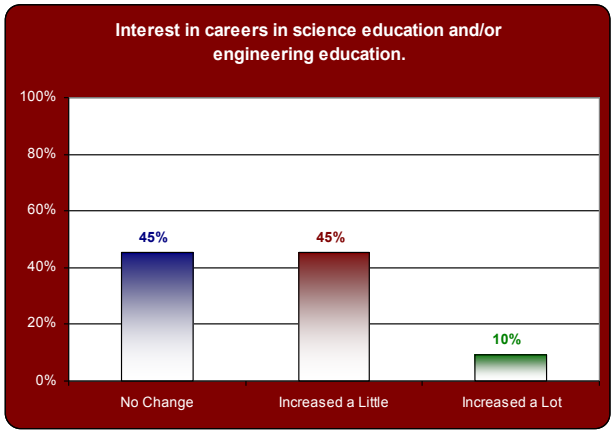
Students were asked how their level of awareness and interest in certain areas changed due to their participation in the 2009 summer research experience. Eighty-two percent said that their awareness of broader societal implications of new technologies related to nanotechnology increased a lot or a little. Sixty-three percent said that their interest in pursuing a graduate level degree related to nanotechnology increased a lot or a little, while 32% reported no change and one student reported that his or her interest decreased a little.

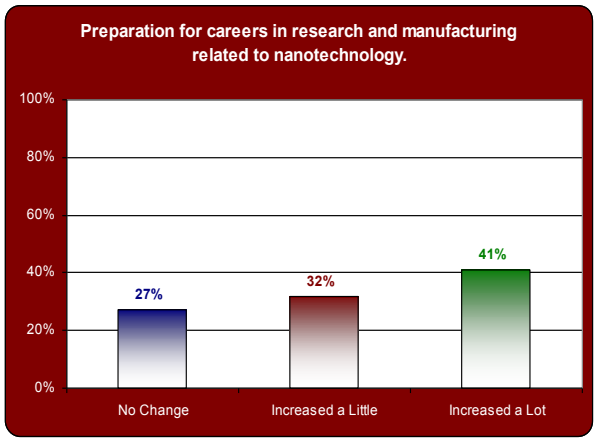




Eighty-two percent reported that their interest in finding a career in research and manufacturing related to nanotechnology had increased a lot or a little. Fifty-five percent reported that their interest in finding a career in science education and/or engineering education had increased a lot or a little, with the remaining 45% reporting no change. Last, 73% of students reported that their preparation for careers in research and manufacturing related to nanotechnology had increased a lot or a little.







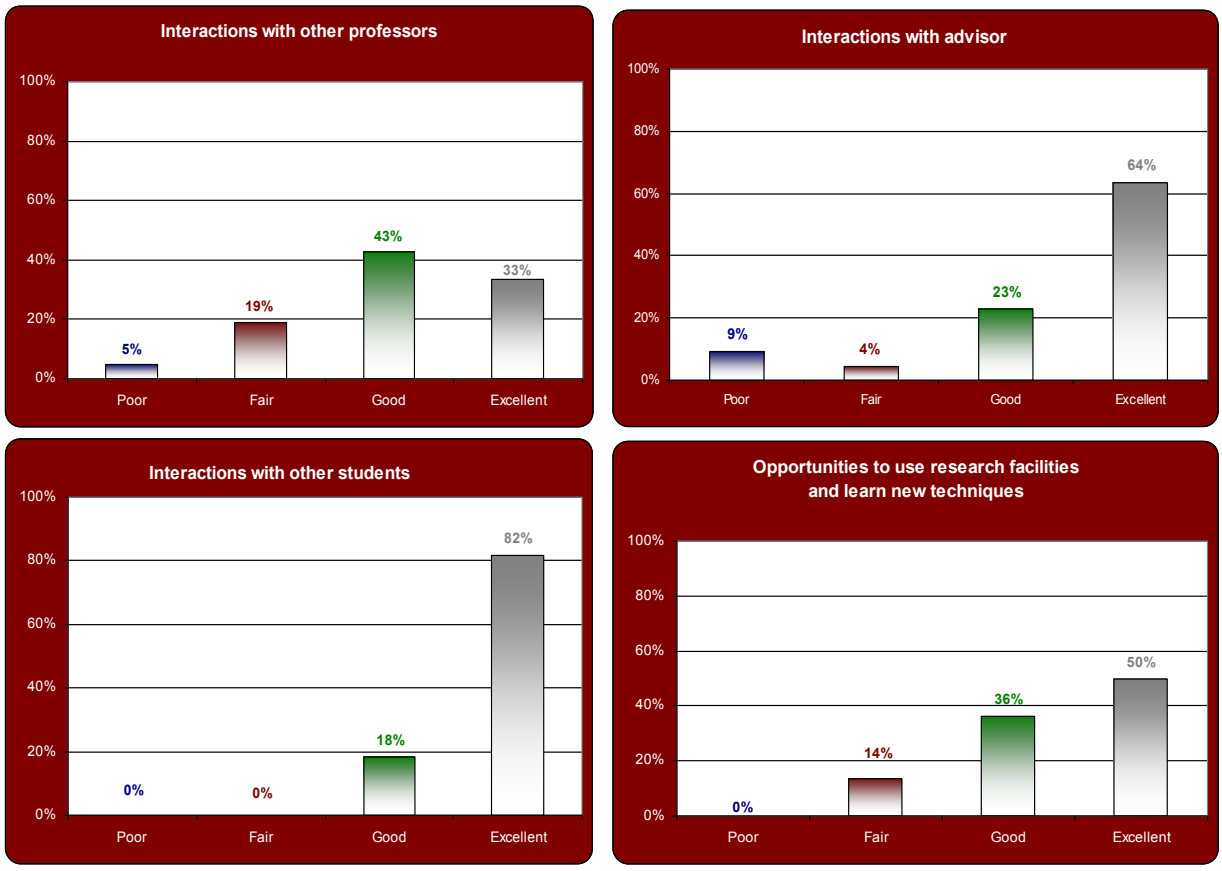
Seventeen students responded to an open-ended question that asked about the program's impact on their academic, career, and future plans. Five said that the experience affirmed their plans to pursue research, or helped them determine whether research was the right path for them. Four reported that the program provided insight regarding what they wanted to do in the future, and four reported that it encouraged them to pursue graduate study. Three noted that the program gave them better skills (e.g., taking notes, writing papers, and making presentations). Two said that the program introduced and encouraged pursuing the field of nanotechnology, and one said that the program highlighted the importance of science and real world applications.

Students were asked two questions similar to this topic during focus groups -- how the REU program influenced their desire to do research and specifically how it influenced their future career and research plans. For some students, the experience confirmed that they liked research and wanted to keep doing it, and most said that they would at least consider doing research in the future. Regardless of whether students wanted to pursue a career in research, the REU program helped identify fields and roles of greatest interest to them, as well as areas they wanted to avoid, and to hone their professional ideas and plans. For instance, one student decided that he wanted to do research but realized that he preferred to focus on development rather than pure science. Another student had not previously wanted to "spend his life in a lab," but the REU changed his mind. Many students felt that the program helped them

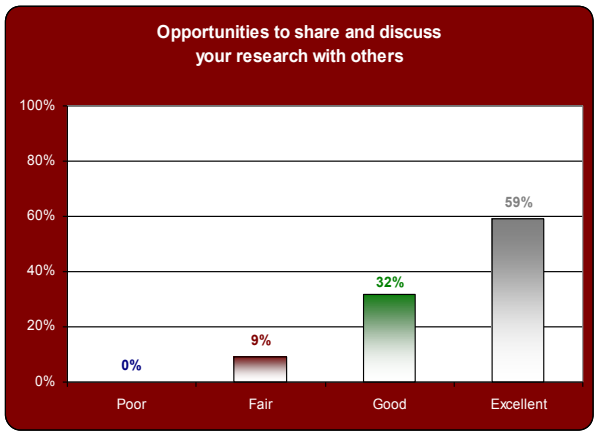
understand what research entailed, increased their confidence in their research topic, and gave them a broader knowledge base and valuable experience working in a lab setting.

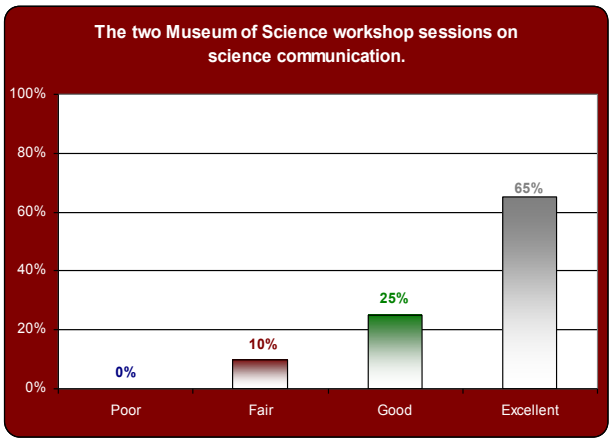
Student Impressions

Students were asked to rate several aspects of their summer research experience. Eighty-seven percent rated their interactions with their advisors as excellent or good, and 76% rated their interactions with other professors as excellent or good. All 22 respondents rated their interactions with other students as excellent or good.

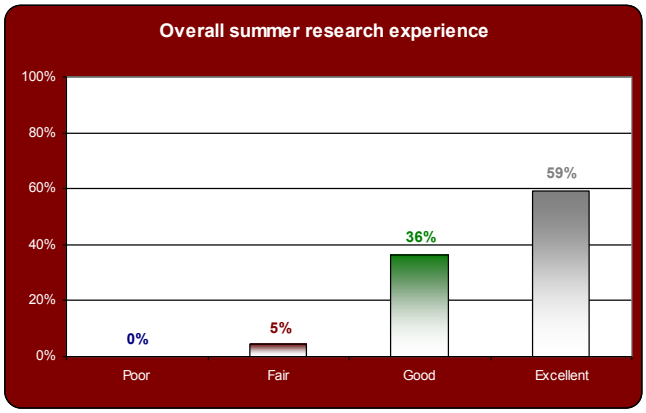


Student perceptions of opportunities were positive: 86% reported that their opportunities to use research facilities and learn new techniques were excellent or good, 91% rated their opportunities to share and discuss their REU research with others as excellent or good, and 82% rated the Museum of Science Communication Workshops as excellent or good. When asked to rate the housing, most students (N=14) said it was not applicable to them. Most of the rest said it was excellent (N=7) and one said it was poor.

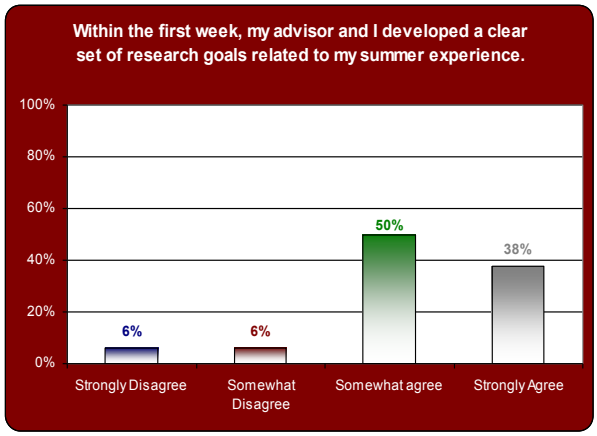


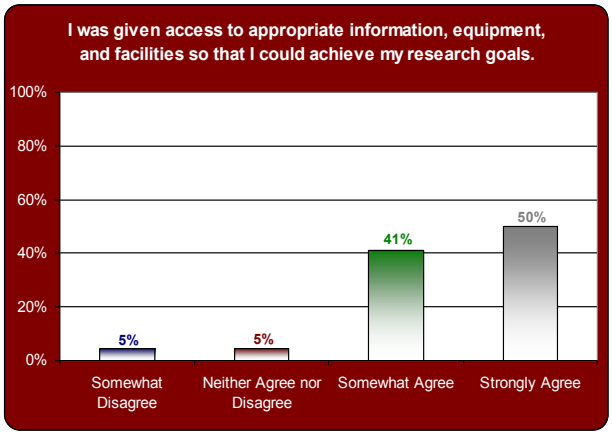


Rating the overall summer research experience, 95% (N=21) rated it as excellent or good. Only one student rated it as fair, and none said that it was a negative experience.

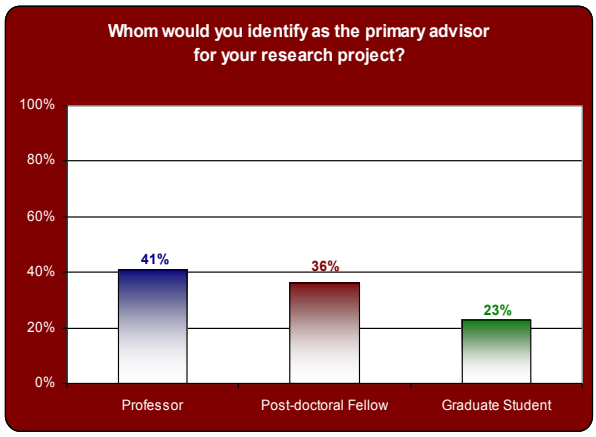


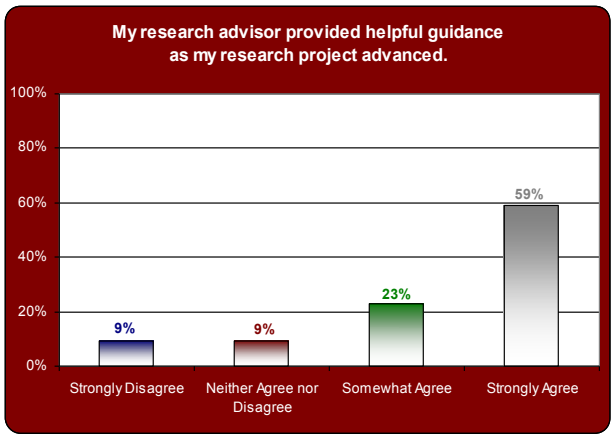
Students were asked several questions about human and material resources available to them as part of the REU program. Eighty-eight percent (N=14) strongly or somewhat agreed that within the first week they and their advisor developed a clear set of goals related to their summer experience. Ninety-one percent strongly or somewhat agreed that they were given access to appropriate information, equipment, and facilities so that they could achieve their research goals.





When asked whom they would identify as the primary advisor of their research project, responses were 41% professors, 36% postdoctoral fellows, and 23% graduate students. Eighty-two percent strongly or somewhat agreed that their research advisors provided helpful guidance as their research projects advanced.





Feedback on Program Components

During focus groups students were asked to share their impressions of several program components. Those components are discussed next, except for the Science Communication Workshops, which were assessed in more depth and are presented in a separate section.

1. Ethics in Nanotechnology Session - Students from NEU said they were pleasantly surprised with Dr. Sandler's session and found it informative and helpful. One participant noted that the session was positive mainly because of the attention-grabbing way it was presented, which opened students' minds to the topic. One student disliked it because he wanted the professor to go into more depth, but other students disagreed and focused on the main take-home points of the session. One student didn't understand why the ethics session was presented, given the ambitious scope and tight deadlines of their projects.

Students from UML said that the lecture gave them things to think about, but some did not think it was very relevant to their REU experiences. Their main grievance with the session was technical. The session took place at NEU, and the UML students, who participated via teleconference, felt it was too impersonal because technical difficulties prevented them from being able to see the lecturer. They suggested having the session at the Museum of Science in the future with all students in attendance.

2. Writing an Introduction Session - Some students said that they didn't take the Writing an Introduction session or paper very seriously because it was not being graded and making progress on their REU projects took precedence. Many students felt that writing a literature review was a valuable experience, but some suggested offering this session later in the summer when they had more knowledge of their research and were far enough along in their projects to be able to think about other priorities. UML students again reported that the session was done through teleconference which was less engaging than a face-to-face presentation.

3. The "More-or-Less Weekly" Meetings - Some students at both NEU and UML were unsure what meetings this question referred to, but they believed it was probably the REU meetings that were supposed to be once a week on a Thursday or Friday. The frequency of these meetings varied: some students said that they had not had any such meetings, and others said that these meetings were not

weekly. One student reported having three meetings per week, and another had regular meetings weekly via Skype. One participant reported having meetings with a graduate student mentor for the first two weeks to summarize what was being done. Another student had weekly meetings in which he gave presentations and received feedback on how to plan experiments. Other students did not have formal weekly meetings, but they interacted with their advisors regularly and informally. Students who did have regular meetings with their advisors found them very helpful for planning experiments, getting feedback on their work, and making progress on their projects, as well as for learning about what other members of their research teams were doing.

4. Other Program Components - Students mentioned a symposium/workshop in which professors from all over the world talked about their research. Students could choose to go either on a field trip or to the symposium, and students who chose the symposium said that it was a positive experience. UML students also mentioned a few other meetings, such as a talk about PowerPoint presentations given by Professor Barry, a safety training, and a library training. The library training was helpful for students who were just at UML for the summer, but matriculated students had already done the library training twice. Students agreed that the internal meetings and presentations were useful but not as unique or beneficial as outside events, such as the Museum of Science workshops.

Program Strengths

Through the focus groups and web-based surveys, students were asked to comment on the strengths and challenges of the REU program, as well as their suggestions for change. Their responses with regard to program strengths are summarized first.

Of the 17 web-based survey respondents who commented on the strengths of the REU experience, six noted the seminars and workshops, four cited the opportunities for interaction and collaboration with other students, three noted the experience with public speaking and communication, two cited the hands-on research experience provided, and two noted general learning as a significant strength of the program. Other answers included insight into the research world, the opportunity to work independently, and Dr. Barry (N=1 each).

In focus groups, students said that the opportunity for hands-on learning was the best part of the REU program. They were able to experience their subject in ways that classroom-work alone could not have provided. Unlike in school settings, in which the outcome of experiments is already known, REU students were able to experience more realistic experimental conditions. Students enjoyed the independent aspects of their research projects but also enjoyed collaborating with other students and learning about their projects, which broadened their knowledge of the field and gave them ideas about work they might like to do in the future. Students also valued the Science Communication Workshops offered by the Museum of Science.

Students were also asked "If you were to give an award to the REU program, what would it be for?" One participant, an international student, reported that he would give an award to the program for providing experience in writing papers and doing presentations, as he had not previously been trained in those areas. Another student would give the program an award for creating curiosity in nanotechnology. One participant said that the award would be for overall excellence and for opening up students' minds to science and giving a bigger picture view of science. Other students would give the program an award for giving them the opportunity to meet diverse people, do hands-on work, and "user-friendliness" in terms of the ability to adjust and get involved in their projects (despite some frustrations in this realm). Finally, students commended the program for teaching communication skills. As one participant explained,

"before the REU, I had trouble explaining to other people what I was doing, what I was studying… now I can explain more easily what I'm doing."

Program Challenges

On the web-based survey, 18 students commented on challenges of the REU experience. Seven cited a lack of organization, coordination, or communication. Two said it was challenging that the results of their experiments were unexpected or unable to be included in their presentations. Two cited challenges related to lack of notice and/or planning in the beginning of the program, and two said that there were no significant challenges in the REU program. Challenges cited by one student each were lack of field trips directly related to nanotechnology, lack of clear procedures in the clean rooms and laboratory, an advisor who did not take any interest in teaching, and the fact that foreign students were not paid for participating in the REU program.

In focus groups, students noted the challenge that their work was dependent on their advisors, who could be challenging to get in touch with if students wanted to check if they were on the right track and get advice about next steps. Students also said that some of their experiments were dependent on someone else's work, which at times delayed their own progress, leaving them with "nothing to do" and "dead time". Challenges with advisor response time were especially true in the beginning of the summer, and although students understood the importance of spending time reading background information, they were still frustrated with the inactivity of the initial weeks of the program. Since REU participants did not have the authority to order materials, students sometimes had to wait until their professor was able to order for them, causing more delays and frustration. One student expressed frustration with an advisor who told the student to read papers while he took images in the scanning electron microscope, which took weeks. Some students felt that advisors, postdoctoral fellows, and graduate students didn't care about the REU student's work, although others said their advisors were more receptive.

Students also expressed frustration with disorganization, particularly at the start of the REU program. Some students reported that they did not even know that they were part of a program that involved required trainings, meetings, presentations, and other activities. They knew they were working for a professor during the summer but didn't know about the REU program itself until one day they were told that they were part of the program and were expected to start participating in program activities immediately. They felt that some of their professors also did not know about the details of program participation. This particular set of misunderstandings apparently applied to most of the UML students who were not working in plastics engineering.

Working with equipment was sometimes challenging, either because it took too long to receive the training required before using the equipment, or because the equipment was malfunctioning, especially the scanning electron microscope (SEM). Finally, some students were frustrated with not being able to obtain good results. One student mentioned that he/she could not get results from the project before the program ended, which presented a problem with the requirement to give a presentation on the project.

Program Suggestions

On the web-based survey, 14 students made suggestions for improving the REU program. Four students suggested having more field trips, four suggested more information and planning before students arrive at the REU, three suggested better communication and/or organization, and two suggested more seminars. The remaining suggestions, each offered by one student, included scheduling equipment training to be completed during the first week of the program, having CHN graduate students and post docs present the projects that they're working on, having more than one post doc as an advisor, having meetings and

planning sessions with the post docs, and giving more consideration to the types of jobs assigned to students (e.g., not only testing but also fabrication).

In focus groups, students offered two suggestions for the problem of having too much down time -- setting up smaller projects that could be pursued in the event of a delay with the primary project, and having a second-in-command other than the primary advisor who could order materials or give direction if needed. Students also suggested more seminars to provide deeper context for their summer work. One student specifically mentioned that it would have been helpful to have a seminar on carbon nanotubes and other important background information, because professors and researchers who have been in the field for a long time tend to forget that some students lack this key background knowledge.

While students enjoyed the field trip overall, they noted that the company they visited was not directly related to nanotechnology. They conjectured that this was because the field trip was organized by a different center at NEU, rather than being organized by CHN. They would have liked the field trip better if it had been more related to nanotechnology and their specific research. Students also suggested having their professors be more accessible, although they acknowledged that the professors were very busy. One participant reported that he was able to attend meetings with his professors every week, and in that time was able to see informal presentations about the work of everyone in his research group. He said that if others had been given that opportunity it probably would have given them a better learning experience.

Some students believed that if they had known their project topics and had an outline or schedule before the summer program began, the transition would have been smoother and they would have been more efficient, possibly leading to a more conclusive finish. To remedy various organizational challenges, students suggested assigning a staff member to be in charge of coordinating the REU program. Last, students suggested time to interact with the REU students at the other campuses, as their time to share projects was limited.

In the focus groups, students were asked what they wished they had known before starting the REU program, and what advice they would offer to next year's students. Some students wished that they known more about their projects before the program started, so they could have gathered and read background information before arriving, as well as general prerequisite knowledge about nanotechnology. They also would have liked to know logistical information ahead of time, such as the program schedule, where to go, and what to expect on the first day. Some students would advise future REU students not to enroll in summer courses, because that reduced their ability to focus on their REU projects. Others suggested starting the REU project before the beginning of summer or continuing it into the school year if possible.

The biggest suggestion for future REU participants was to take initiative with their advisors, since the advisors and graduate students have multiple projects happening at once and assertiveness helped REU students to get more involved. Students recommended that future participants promptly introduce themselves to the graduate students, professors, and staff involved in their project and show their interest early on. They also recommended reading about the topic before arriving for the REU so that students can immediately ask questions about aspects they had difficulty understanding. This gives students a good foundation and creates a good impression on advisors, creating more incentive to help students along. Participants also said that understanding cultural differences was important.

Science Communication Workshops

The Science Communication Workshops held at the Museum of Science were a central educational component of the REU program that were subject to more extensive evaluation than other program

components. In addition to questions about the workshops in the web-based survey and focus groups that students completed at the end of the program, students completed surveys at the Museum of Science at the beginning and end of each of the two Science Communication Workshop days, and phone interviews were conducted about the Science Communication Workshops with several key REU program stakeholders. Findings from this array of measures are reported below.

Key Stakeholder Interviews about Science Communication Workshops

Key stakeholders in the REU program were interviewed by phone, soliciting their feedback about the Science Communication Workshops using an interview protocol developed by the director of the workshops at the Museum of Science in collaboration with UMDI (Appendix C). These stakeholders included the CHN Director (Professor Ahmed Busnaina at NU), CHN Associate Directors (Professor Carol Barry at UML, Professor Jacqueline Isaacs at NU, and Professor Glen Miller at UNH), the Museum of Science staff who conducted the workshops (Strategic Projects Director Carol Lynn Alpert and Education Associates Alex Fiorentino and Karine Thate), and, from the Nanoscale Science and Engineering Center at Harvard University, Principal Investigator Professor Robert Westervelt and Site Coordinators Professor John Free and Dr. Kathryn Hollar. (A cohort of REU students associated with the School of Engineering and Applied Science at Harvard University attended Science Communication Workshops during the same time period as the CHN REU students, and survey data were also collected from those sessions, but analysis of that data is outside the scope of this report to CHN.)

1. **REU Program Leaders** - When respondents were asked in what ways they hoped the Science Communication Workshops would benefit the students, they responded that students need better oral and written skills for communication with scientists in their own field and in other fields, as well as with the public, and that most scientists receive inadequate training in these areas. Needed skills include being more comfortable speaking in front of an audience, using less jargon, understanding the knowledge and perspective of your audience, and presenting in ways that make your audience appreciate and care about the issues you're presenting about. An additional benefit is that the workshops help students write more clearly which increases their chances of getting papers published and grant proposals funded. Last, the workshops provided a structure and deadlines for students' required REU presentations, which motivated them to start sooner and produce higher quality work.

Respondents explained that good science communication skills are important to the success of science careers because students need to think through their work carefully and be able to explain it before convincing others to support it both morally and financially. Being able to express themselves is required for ABET engineering certification and is also personally empowering. Most felt that this has been a neglected area of science training, separated from the main curriculum, but that the problem is gradually improving. Communication skills will also help during poster sessions at conferences, where students too often dive deeply into their material before giving the larger context in which their research fits, but that the workshops helped students see the importance of providing that context. Good communication skills were seen as particularly important in the field of nanotechnology because students will often have to address colleagues who aren't familiar with their specific disciplines, because nanotechnology has fewer straightforward applications than other scientific subdisciplines, and because nanotechnology is too small to be seen and therefore requires very clear explanation.

Respondents explained that in addition to helping students, offering science communication training to students also benefits the faculty, department, center, and university. Students communicate better with faculty and with each other, and one respondent noted that many students become better communicators than their faculty supervisors. When students become better writers and presenters, faculty feel more

comfortable sending them to conferences, spend less time revising their papers, and can focus more on the technical aspects of scientific training.

Respondents were also asked what value the Museum of Science involvement in the training adds beyond what is already provided by university faculty and staff. They responded that the students tend to listen to outsiders more than to professors, that the museum has credibility with the students, and that it's good for students to see STEM professionals who pursued a career path in education. A change of venue away from the university is also engaging for students, and gives them an opportunity, at least briefly, to stop thinking about course grades and instead think about the big ideas and benefits related to their work. Respondents added that the museum staff are talented, professional presenters who tell good stories, know better than professors how to explain science to the general public, and are "natural hams" in ways that many professors aren't. Finally, for students who later become educators, observing the museum staff help them design experiments that can illustrate important scientific points.

When asked how the workshops could be modified to better meet student or faculty needs, one suggestion was that the museum personnel and perhaps other panel members should be more critical and ask harder questions in the activity when students are presenting their five slides. One respondent said that museum staff should ask students more about what they want and need, but followed up by saying that the surveys accompanying each workshop filled this need to some extent. Other comments were that the workshops felt targeted to a somewhat younger audience, such as the "breathe-in breathe-out" activity, that the workshops should be shorter, and that rules of presentation (e.g., the dos and don'ts) should be given sooner. One respondent suggested that the workshops should be more hands-on and include an evaluation component to sure that students have learned what was taught.

Feedback overall was very positive. Respondents felt that the workshops were very valuable to students and they wanted to offer similar workshops to their graduate students and even to the faculty in their departments. They felt that the museum staff had been very responsive and actively solicited feedback, and that the workshops were worth disseminating to other museum/university pairings such as those in the NISE network.

2. Museum of Science Staff - The museum staff who designed and conducted the Science Communication Workshops also responded to evaluation questions that they had developed. When asked what worked best about the workshops they mentioned holding the two sessions at the museum, having a group size of 20 rather than 40 (referring to the Harvard REU group, which was larger than the CHN REU group), making sure that groups arrive on time and mostly together, and additional logistical details which presumably will be integrated into their implementation manual. Effective program components included teaching how to offer constructive feedback and address broader audiences, providing opportunities to actually speak and write, debriefing an (intentionally) bad presentation, explaining their research to each other in small groups, helping students with difficult topics frame the explanations of their work while other students watched, offering feedback on research presentations, and the "elevator speech" activity that directed student attention to the "big picture" of their work including basic concepts and what challenges their research was directed at solving.

When asked what turned out worse than expected, the museum staff noted that students didn't remember or do their homework, perhaps because they don't pay attention to written documents and need to receive the information electronically. The museum expected that students would be receiving powerpoint training elsewhere, but that didn't happen, so that needs to be coordinated in the future. They felt that the voice and physical exercises were valuable and enlivening, but resisted by the students, so they wondered how to increase student interest in this. They felt that modeling a good presentation was unnecessary, because the modeled bad presentation made the important points adequately and with greater student

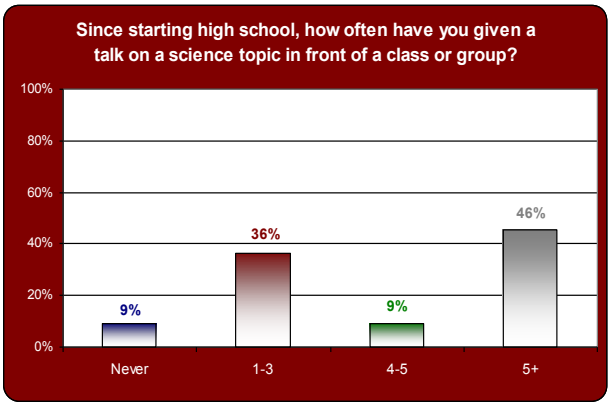
engagement. Finally, at the second workshop students needed review time before presenting their elevator speeches.

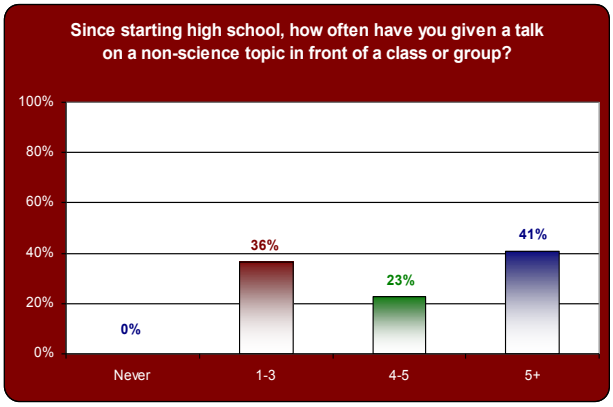
Additional modifications the museum staff wants for next year include electronic contacts (e.g., cartoons, wikis, emails, web links) with students between the two sessions, including brief homework reminders; wikis to gather presentations into projectors more effectively; clarification of who is preparing the students for their poster sessions; timekeepers to ensure that the 15-minute research presentations apportion five minutes for each of the three components (i.e., presentation, reflection sheets, and debrief); specific guidance on how to provide thoughtful feedback; a green laser pointer for the Bad Presentation; and drinks and snacks for the afternoon session.

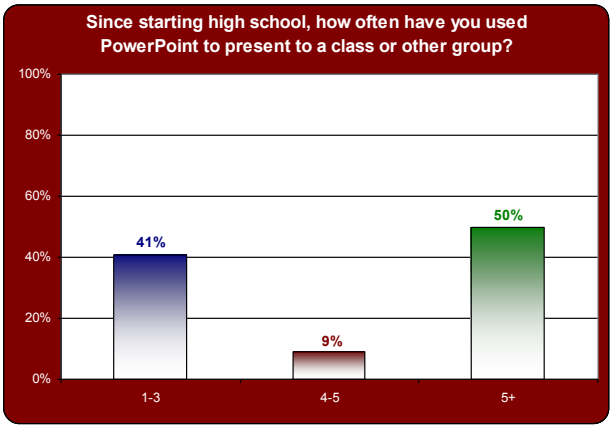
Additional help that the museum staff would like to have from the faculty includes quicker responses (although CHN was much better this year), accurate listing of the workshops on the REU student agenda, names and affiliations in advance (for nametags), access to student emails and wikis, support in getting students to complete their homework assignments, participation of all faculty in each session, help with guidance of students during workshops, and clarity and coordination about CHN expectations for final presentations. One suggestion was to invite additional faculty or grad students to sit in on practice presentations to provide "scientific expertise," but to make sure that these experts don't take over the critiquing sessions so that the focus remains on students developing peer feedback skills.

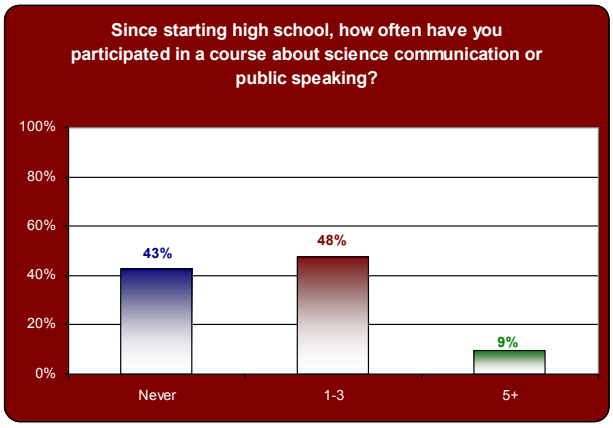
Student Feedback about Science Communication Workshops

1. Session #1 Pre-Survey - REU students completed surveys before and after each of the two workshops (Appendix D). The Session #1 pre-survey asked about demographic information as well as students' skills, beliefs, and priorities related to making science presentations. Fifty-five percent of the students had given a talk on a science topic at least four times since starting high school, and 9% had never given such a presentation. Experience with giving talks on non-science topics was more common, with 64% reporting four or more times and the rest having done so 1-3 times. All students had used PowerPoint for making presentations to a group, and 59% had done so four or more times since starting high school. For 43% percent of the students, the Science Communication Workshops were their first time participating in a course about science communication or public speaking, and most of the rest of the students (48%) had done so 1-3 times.

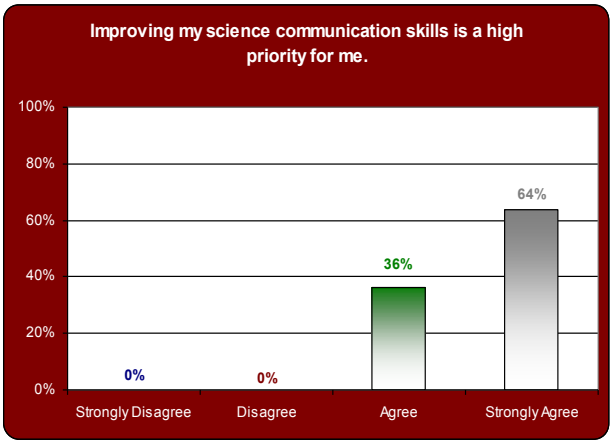


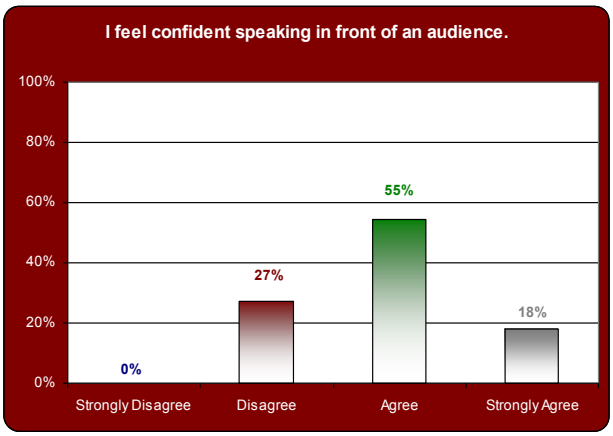


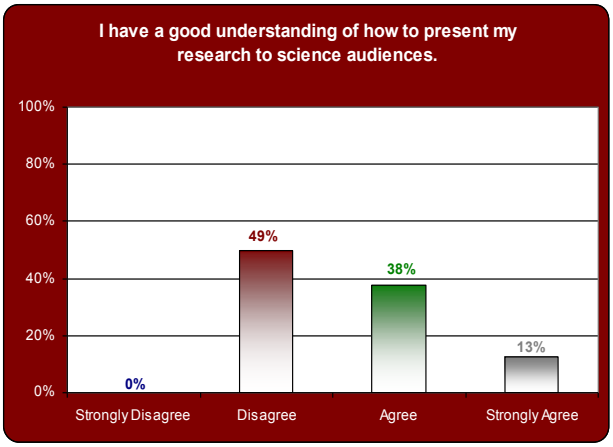


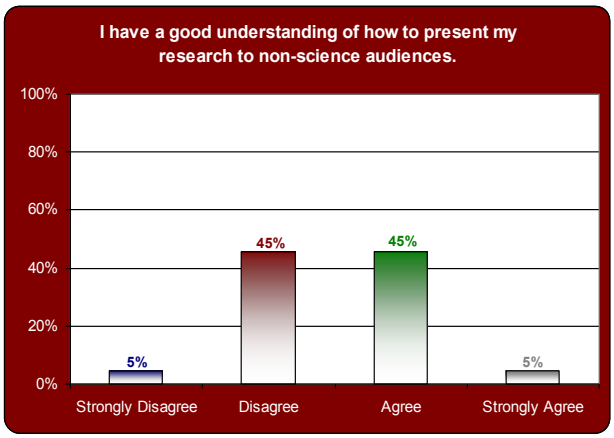


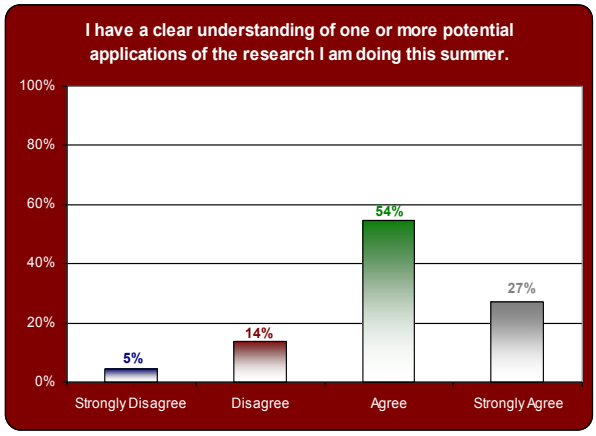
All respondents agreed with the statement "Improving my science communication skills is a high priority for me," and 64% strongly agreed. Most students reported feeling confident speaking in front of an audience, but 27% said they did not feel confident. About half of the students reported having a good understanding of how to present research to a scientific audience, and about half said the same about presenting to a nonscientific audience. Eighty-two percent said they had a clear understanding of one or more potential applications of their REU research, but 18% disagreed or strongly disagreed.







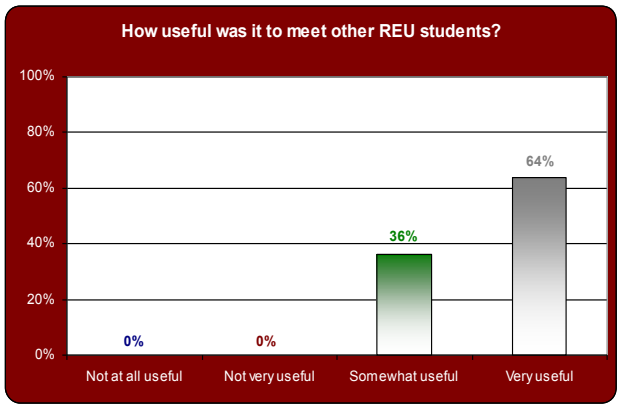


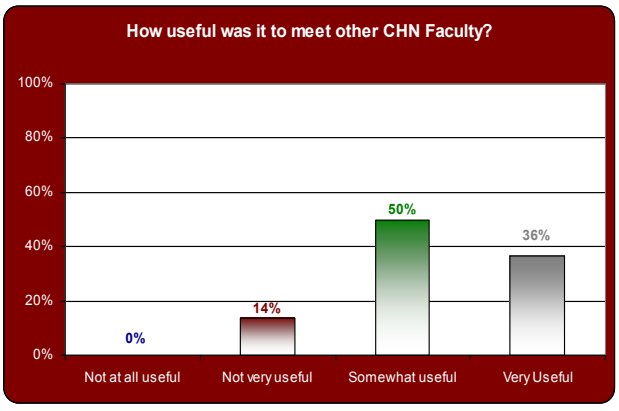


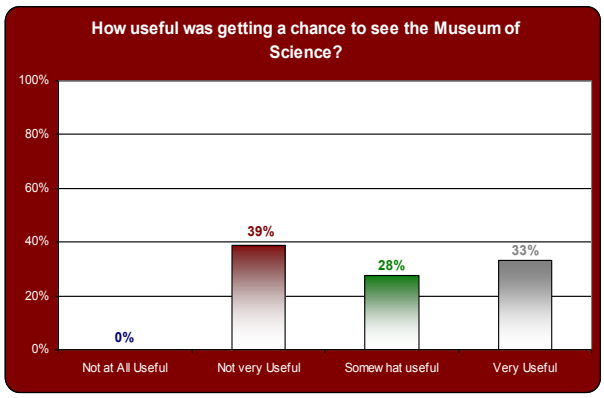
When asked what aspects of presenting science to an audience they liked the most, 11 respondents said explaining science to an audience, teaching what they have learned, and sharing ideas and information. Three said that they disliked making presentations and did not cite anything they liked. Two liked showing real life applications and examples of science, two cited sharing their own interest and excitement about a topic, two enjoyed getting the audience interested in the topic, and two said they liked presenting in general. The remaining answers, cited by one respondent each, were: explaining potential uses and applications, the challenge, and having to understand a topic at a higher level in order to teach it. (Some respondents cited more than one category, so there are more than 22 responses.)

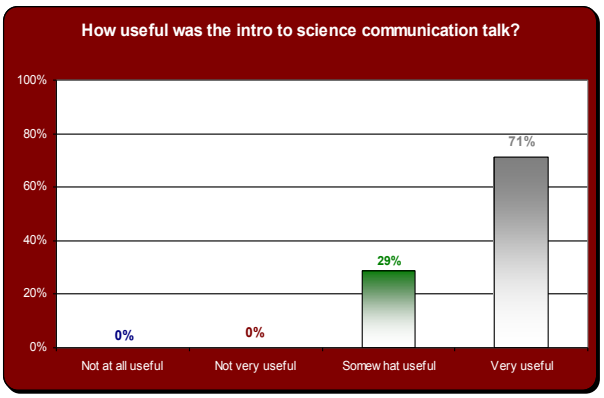
When asked what aspects of presenting science to an audience they liked the least, five respondents cited nervousness about fielding questions after their presentation, and four cited talking in front of people in general. Two cited each of the following: preparing and organizing ideas, not knowing enough, explaining complex details and aspects that they do not completely understand, lack of audience interest, and generalizing for a diverse audience. One respondent each cited background noise, talking about theory, nothing, everything, and general nervousness.

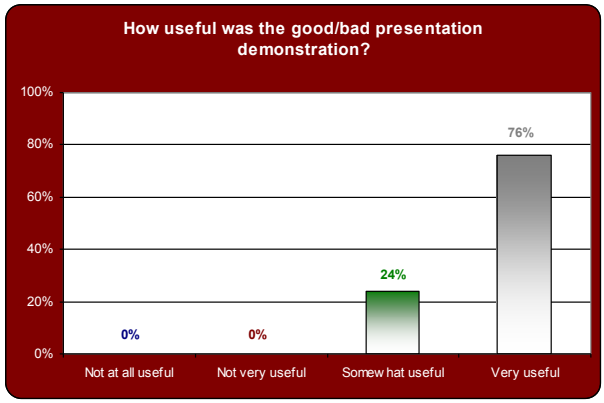
2. Session #1 Post-Survey - Respondents affirmed the usefulness of most Session #1 elements, with 100% rating the introduction to science communication talk, the good/bad presentation demonstration, meeting other REU students, and the context and meaning activities as somewhat useful or very useful, and 85-95% giving those same ratings to the voice and speech exercises, the "elevator talk" exercise, the handouts, and the opportunity to meet CHN faculty. The activity rated as least useful was getting a chance to see the Museum of Science, with two out of three students rating it as not very useful (39%) or somewhat useful (28%). No respondents selected the "Not At All Useful" option for any activity.

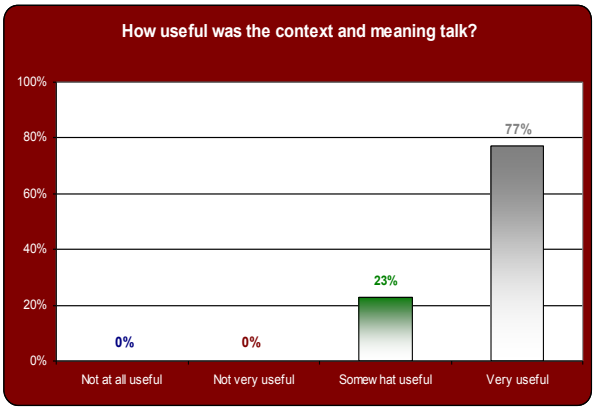


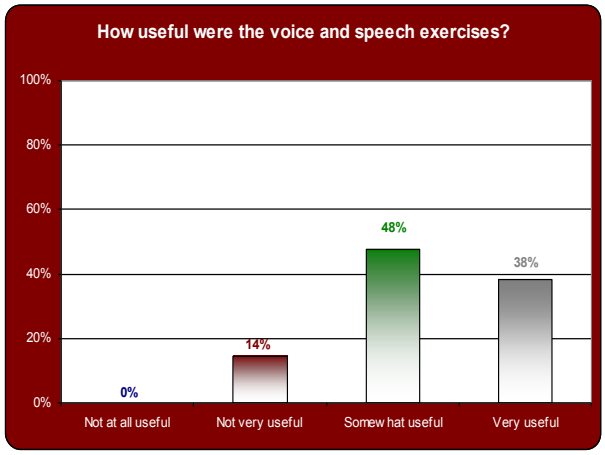


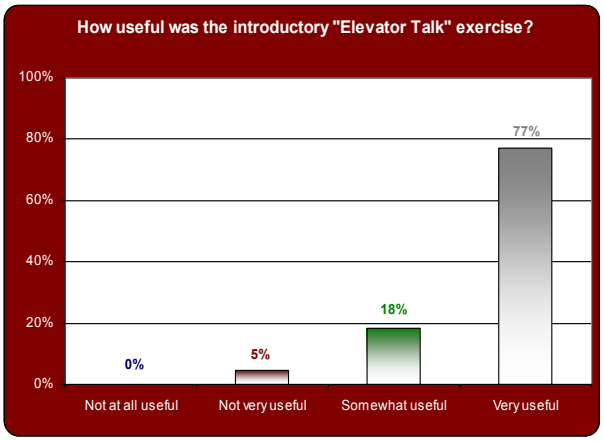

How useful was getting a chance to see the Museum of Science?
100%
80%
60%
40%
20%
0%
0%
39%
28%
33%
Not at All Useful
Not very Useful
Somew hat useful
Very Useful

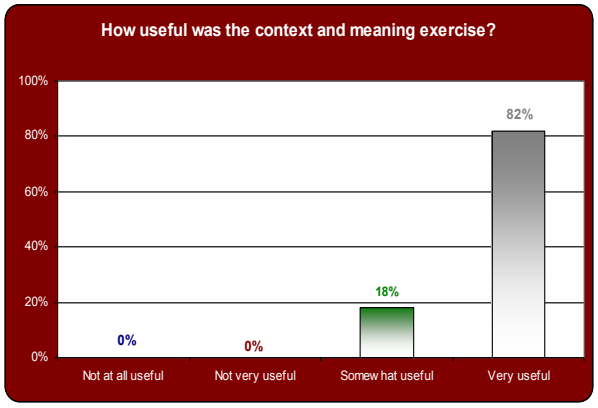

How useful was the intro to science communication talk?
100%
80%
60%
40%
20%
0%
0%
0%
29%
71%
Not at all useful
Not very useful
Somew hat useful
Very useful

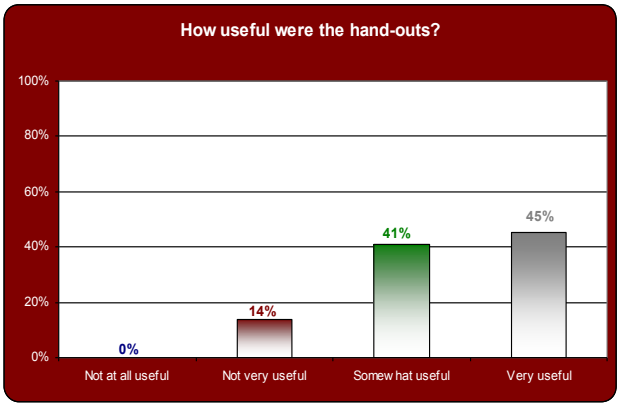

How useful was the good/bad presentation demonstration?
100%
80%
60%
40%
20%
0%
0%
0%
24%
76%
Not at all useful
Not very useful
Somew hat useful
Very useful


How useful was the context and meaning talk?
100%
80%
60%
40%
20%
0%
0%
0%
23%
77%
Not at all useful
Not very useful
Somew hat useful
Very useful


How useful were the voice and speech exercises?
100%
80%
60%
40%
20%
0%
0%
14%
48%
38%
Not at all useful
Not very useful
Somew hat useful
Very useful


How useful was the introductory "Elevator Talk" exercise?
100%
80%
60%
40%
20%
0%
0%
5%
18%
77%
Not at all useful
Not very useful
Somewhat useful
Very useful


How useful was the context and meaning exercise?
100%
80%
60%
40%
20%
0%
0%
0%
18%
82%
Not at all useful
Not very useful
Somew hat useful
Very useful

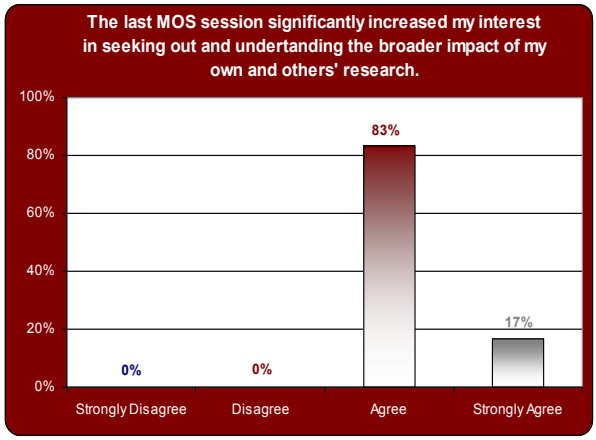

How useful were the hand-outs?
100%
80%
60%
40%
20%
0%
0%
14%
41%
45%
Not at all useful
Not very useful
Somew hat useful
Very useful

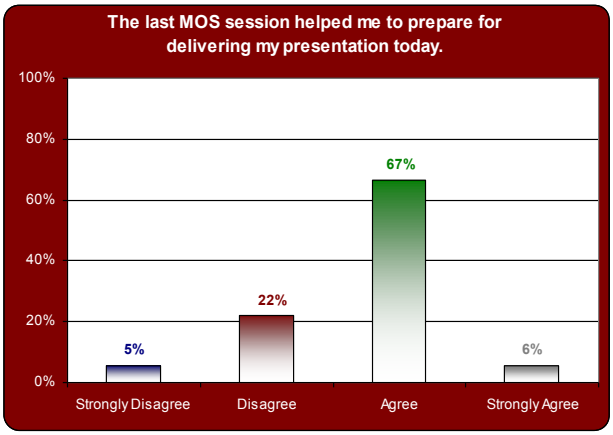
When asked what was most useful about Session #1, seven respondents cited meeting other students, talking about projects with one another, and group practice. Five found practicing explanations most useful, and three thought that talking in front of a large group was most useful. Four said that the most useful part was addressing the importance of the project and why the audience should care. Three cited the context and meaning exercise, and two cited the sample presentations. One respondent each cited practicing communication skills, answering questions, and learning what to say and how to get it across.

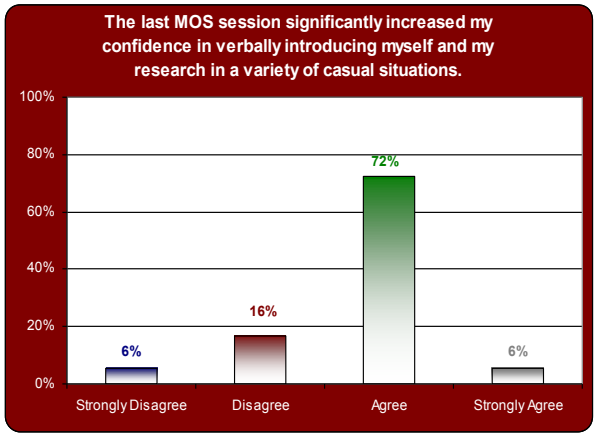
Respondents were asked what topics were not presented in Session #1 that they hoped would be discussed during Session #2, and 17 out of 22 responded. Four requested PowerPoint presentation format and tips and four said that everything was covered or they couldn't think of additional topics. The remaining answers, each cited by one respondent, were how to explain theory simply, researching your research, the number of slides for time frames, handling questions, what to include in the presentation, handing distractions, talking in a more unfamiliar environment, body language, using a poster in your presentation, avoiding being over-technical, and using conferences to develop new relationships. The next question asked for any other recommendations for Session #2, and responses included providing more information on the PowerPoint presentation (N=4), more time with groups doing activities and group exercises (N=2), and one student mentioned each of practicing the poster session, presenting to a completely non-science audience, seeing videos on how to motivate an audience, doing less paperwork, and putting students from different schools in the same group.

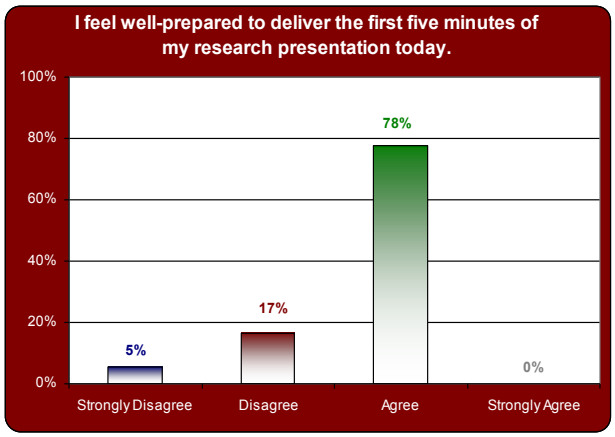
The final question invited students to make any other comments they wished. Nine students responded, and eight offered positive comments, noting that the workshop was useful, fun, and well-done.

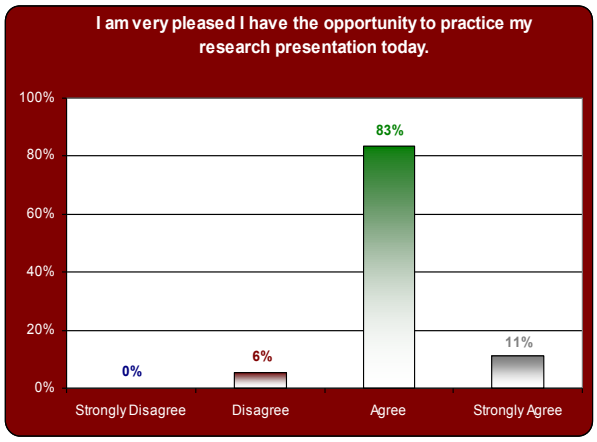
3. Session #2 Pre-Survey - The Session #2 pre-survey asked students to reflect on Session #1, their work between the two sessions, and their preparedness for the research presentation they needed to make during Session #2. All respondents agreed or strongly agreed that Session #1 significantly increased their interest in seeking out and understanding the broader impact of their own and others' research, and about three out of four agreed or strongly agreed that Session #1 had helped them prepare their presentation (73%) and significantly increased their confidence in verbally introducing themselves and their research in a variety of casual situations (78%). Almost all felt well-prepared to deliver the first five minutes of their research presentation (95% agreed or strongly agreed) and were very pleased to have the opportunity to practice it (94% agreed or strongly agreed).



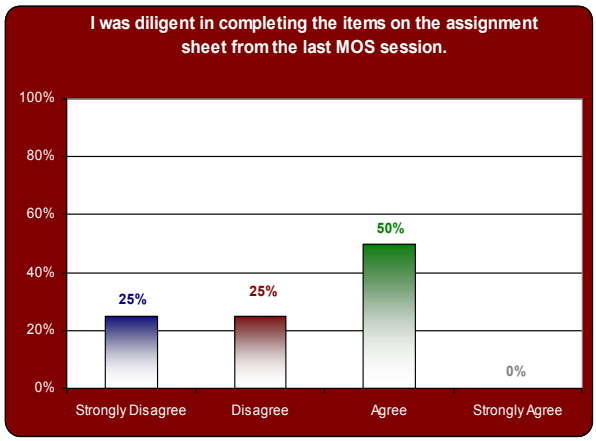


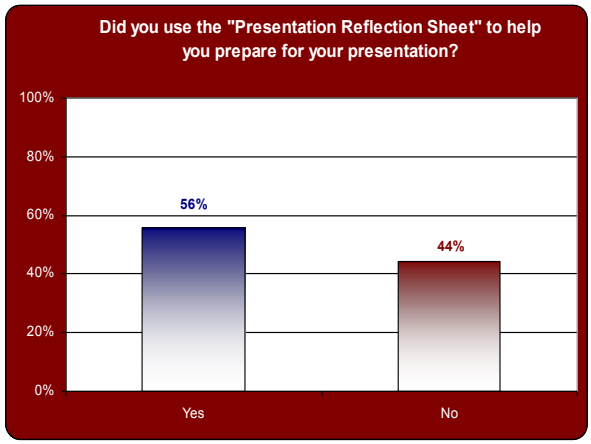


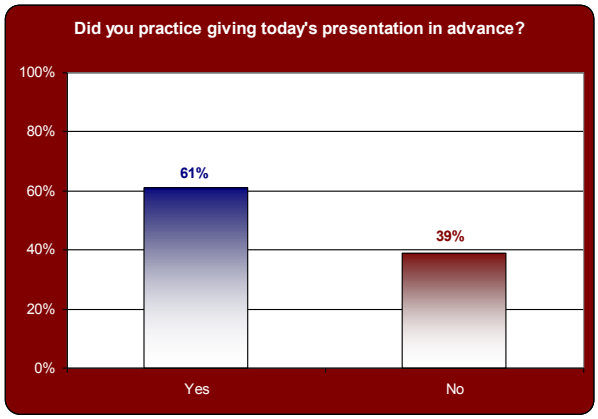


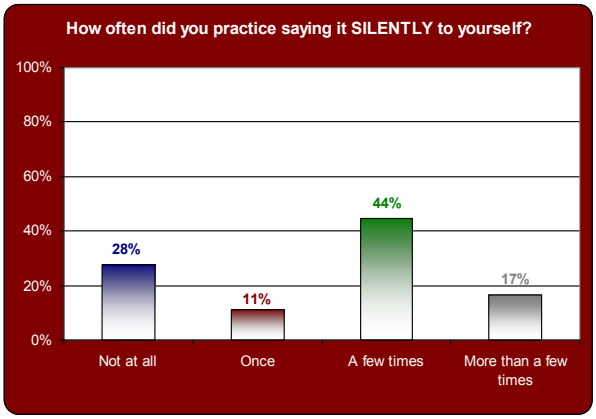


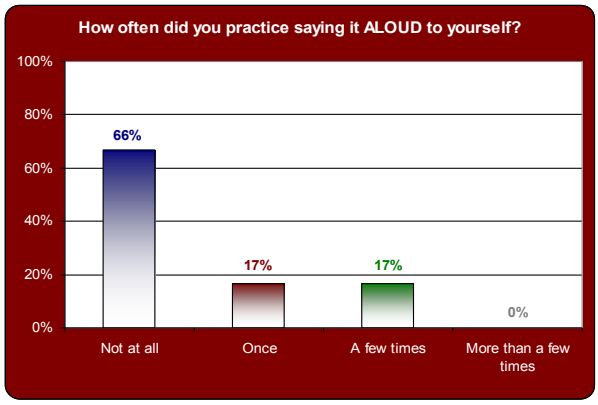
Half of the students disagreed or strongly disagreed that they were diligent in completing the items on the assignment sheet from Session #1, and half said that they used the Presentation Reflection Sheet (56%) and the Poster Session Field Guide handout (50%) to prepare for their own presentations. A larger percentage of students reported using the Presentation Reflection Sheet to reflect on other students' presentations (76%) and practicing their research presentation in advance (61%). Three out of four students practiced their presentation silently to themselves, but only about one in three practiced aloud to themselves (34%) or to others (39%). Most students (88%) reported practicing their elevator speech with themselves or with others since Session #1.

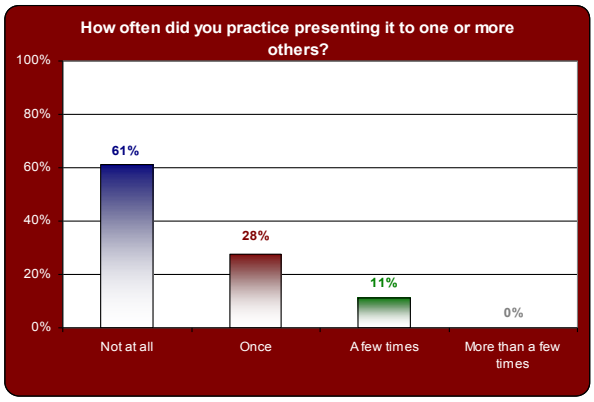


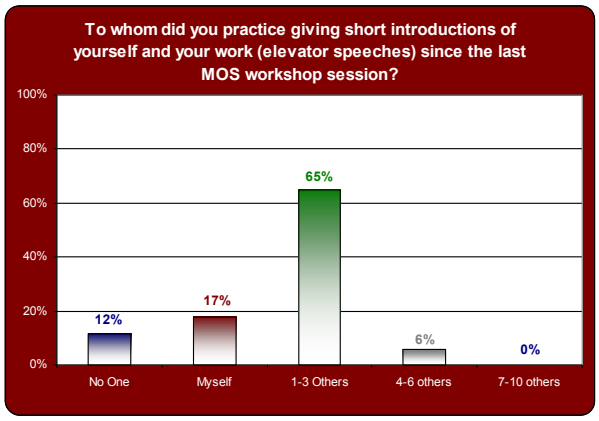


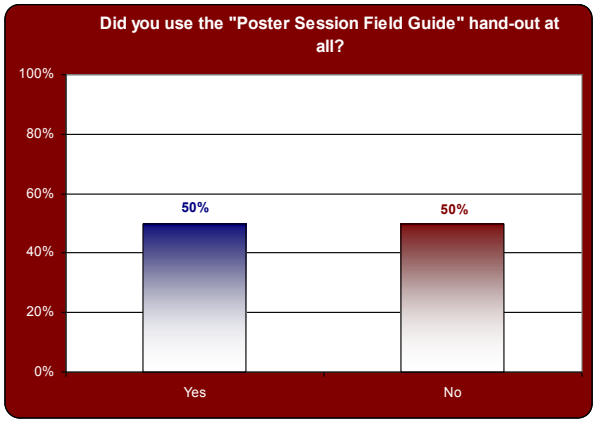

Did you practice giving today's presentation in advance?
100%
80%
60%
40%
20%
0%
61%
39%
Yes
No

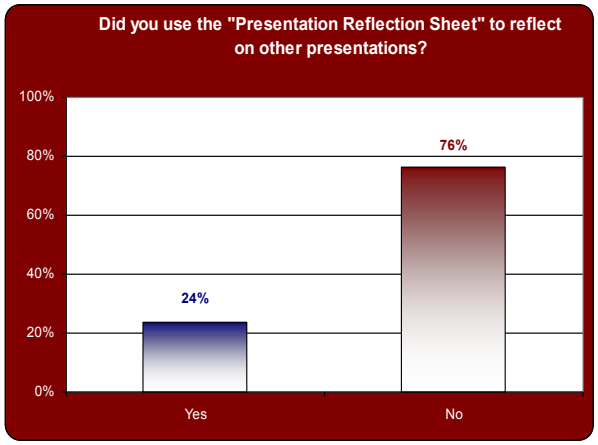

How often did you practice saying it SILENTLY to yourself?
100%
80%
60%
40%
20%
0%
28%
11%
44%
17%
Not at all
Once
A few times
More than a few times


How often did you practice saying it ALOUD to yourself?
100%
80%
60%
40%
20%
0%
66%
17%
17%
0%
Not at all
Once
A few times
More than a few times


How often did you practice presenting it to one or more others?
100%
80%
60%
40%
20%
0%
61%
28%
11%
0%
Not at all
Once
A few times
More than a few times


To whom did you practice giving short introductions of yourself and your work (elevator speeches) since the last MOS workshop session?
100%
80%
60%
40%
20%
0%
12%
17%
65%
6%
0%
No One
Myself
1-3 Others
4-6 others
7-10 others


Did you use the "Poster Session Field Guide" hand-out at all?
100%
80%
60%
40%
20%
0%
50%
50%
Yes
No

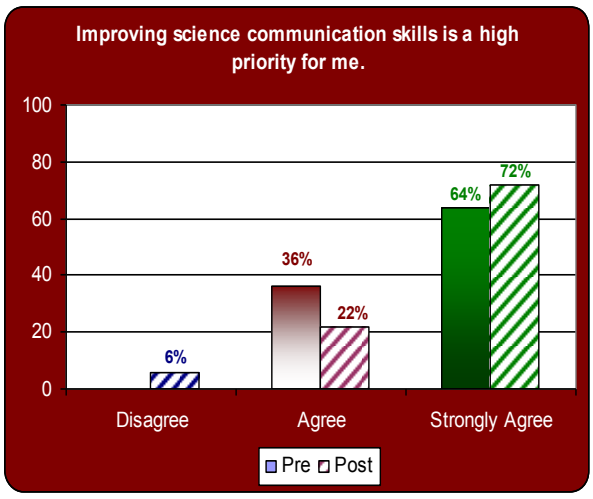

Did you use the "Presentation Reflection Sheet" to reflect on other presentations?
100%
80%
60%
40%
20%
0%
24%
76%
Yes
No

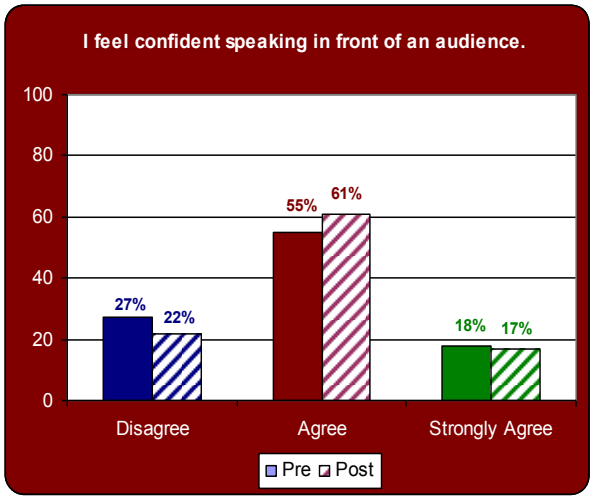
Students were asked what, in retrospect, they found most helpful about Session #1, and eighteen responded. Three said that the PowerPoint tips and "how-to's" were the most helpful, two cited the tips on how to look confident and remain calm in front of a group, two cited meeting other REU students and learning about their projects, and two cited the general presentation techniques. One student each mentioned learning how to simplify explanations, present to an unknown audience, and make an audience care, as well as the Bad Presentation example, the reflection sheet, the outline for slides, the presentation about public communication, and "everything" because it was the participant's first time doing a presentation.

Students were asked to mention recent insights about the challenge of communicating science clearly to people outside their field. Seven reported that explaining their research slowly, simplifying it for the audience, and avoiding jargon were particular challenges. Two mentioned the need to ask questions, and two mentioned the need to use definitions in their presentations. One student each mentioned keeping eye contact with the audience, using examples, being clear, deciding what is most important, explaining the types of materials used, the difficulty of doing elevator speeches with non-science audiences, and inattentive audience members.

4. Session #2 Post-Survey - The Session #2 post-survey repeated the five questions asked in the Session #1 pre-survey about students' skills, beliefs, and priorities related to making science presentations, and the tables below compare their responses before and after completing the two sessions. The first item shows that all students began the workshops with improving their science communication skills as a high priority, and after the workshops the "strongly agree" category increased from 64% to 72%. One student agreed at the outset and disagreed at the end, perhaps believing that the workshops had provided all the communication prowess he or she would need.

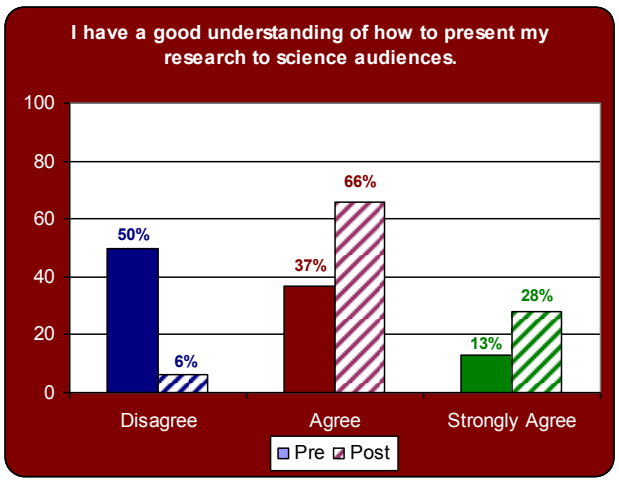
The graph of the second item appears to show minimal pre-post differences in students' public-speaking confidence. A closer look at the raw data shows that about 70% of students showed no difference, 20% gained confidence, and 10% lost confidence. No one's confidence shifted by more than one level.

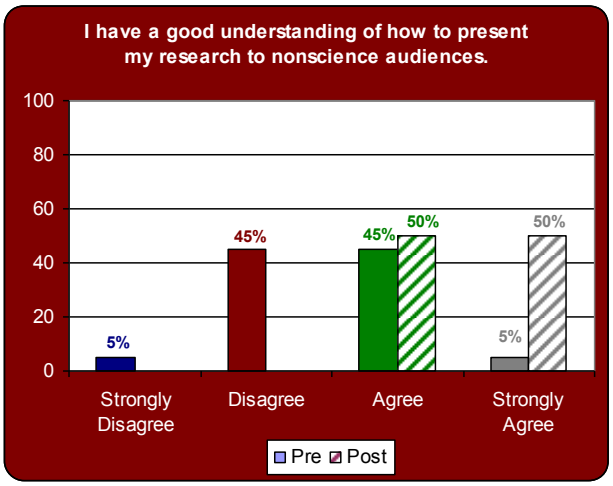


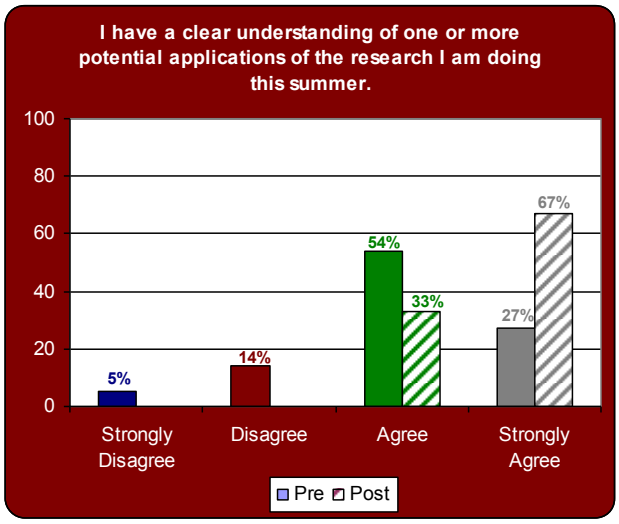


The three remaining pre-post items show the most pronounced changes. Students agreeing that they had a good understanding of how to present their research to scientific audiences increased from 50% to 94%, and students agreeing that they had a good understanding of how to present their research to non-scientific audiences increased from 50% to 100%. Students agreeing that they had a clear understanding of one or more potential applications of their summer research increased from 81% to 100%, a finding

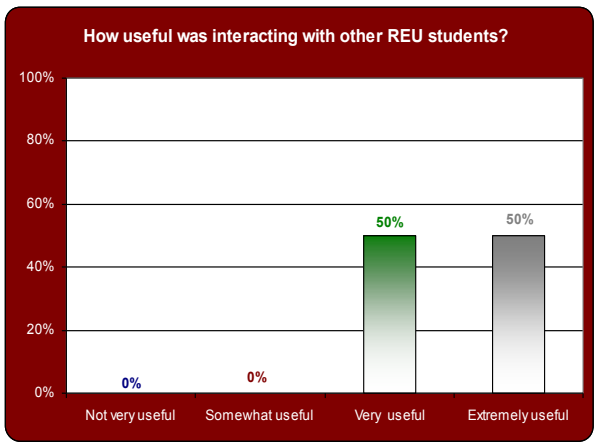
that might be attributable to the Science Communication Workshops but could also reflect the five REU program weeks that elapsed between the two survey administration dates.

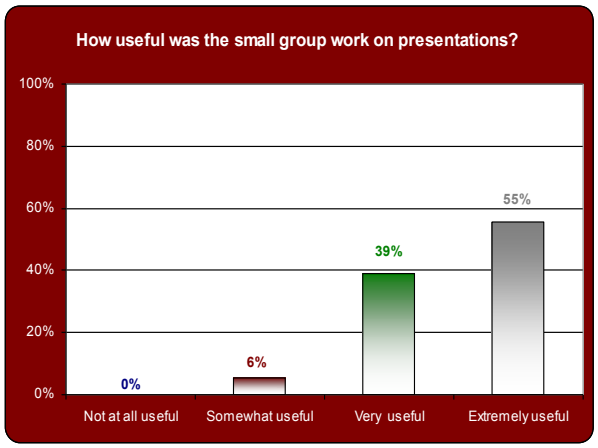


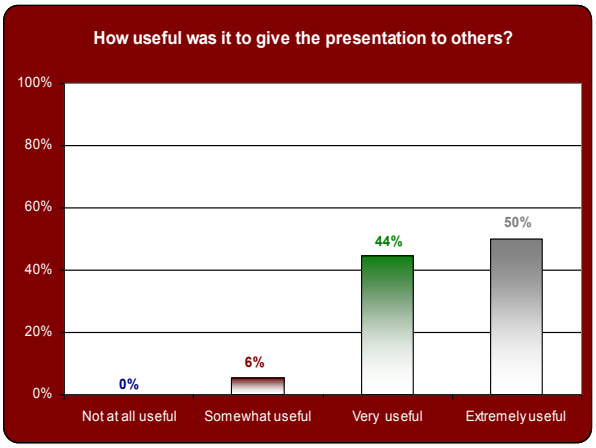


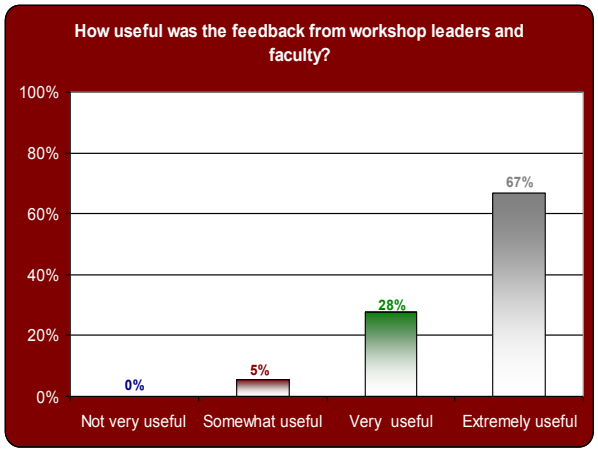


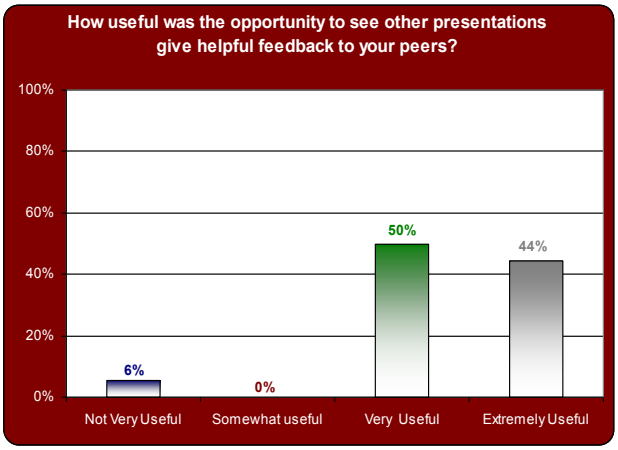
Most Session #2 program components, as well as the two sessions as a whole, were rated as very useful or higher by all but one or two respondents. The only exception was the elevator speeches, which were rated as somewhat useful by four respondents (22%) and very useful or higher by the rest.

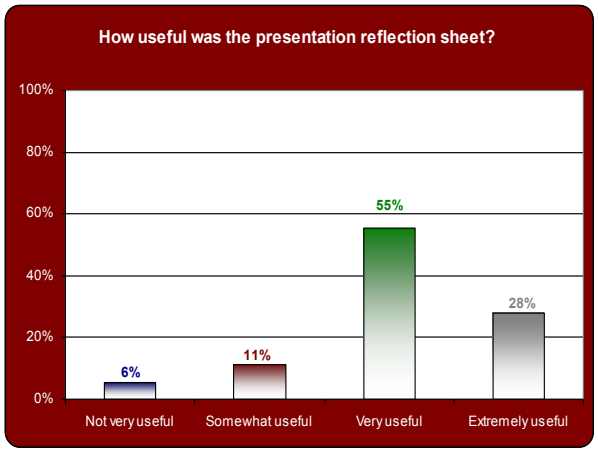


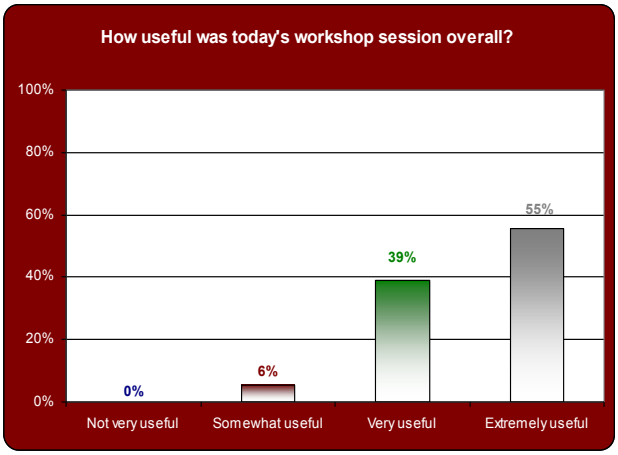

How useful was the small group work on presentations?
100%
80%
60%
40%
20%
0%
0%
6%
39%
55%
Not at all useful
Somewhat useful
Very useful
Extremely useful

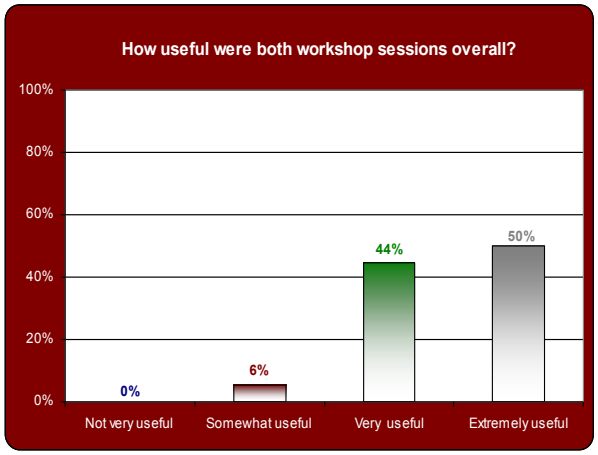

How useful was it to give the presentation to others?
100%
80%
60%
40%
20%
0%
0%
6%
44%
50%
Not at all useful
Somewhat useful
Very useful
Extremely useful


How useful was the feedback from workshop leaders and faculty?
100%
80%
60%
40%
20%
0%
0%
5%
28%
67%
Not very useful
Somewhat useful
Very useful
Extremely useful

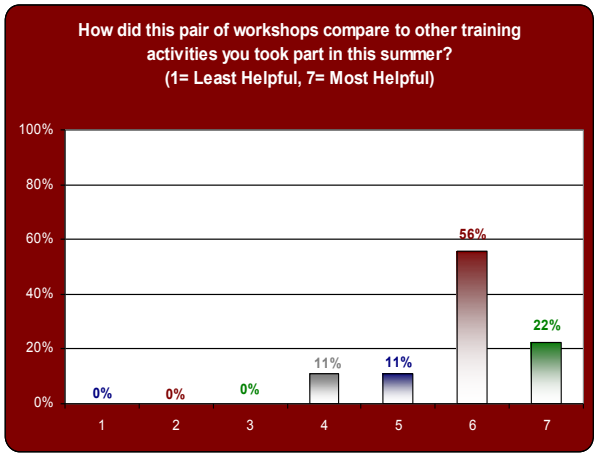

How useful was the opportunity to see other presentations give helpful feedback to your peers?
100%
80%
60%
40%
20%
0%
6%
0%
50%
44%
Not Very Useful
Somewhat useful
Very Useful
Extremely Useful

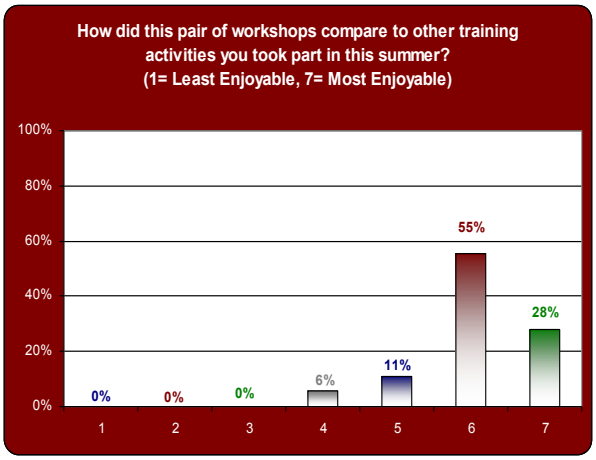

How useful was the presentation reflection sheet?
100%
80%
60%
40%
20%
0%
6%
11%
55%
28%
Not very useful
Somewhat useful
Very useful
Extremely useful


How useful was today's workshop session overall?
100%
80%
60%
40%
20%
0%
0%
6%
39%
55%
Not very useful
Somewhat useful
Very useful
Extremely useful



Students were also asked to compare the workshops to the summer's other REU training activities. On a scale from '1' as 'one of the least helpful' and '7' as 'one of the most helpful,' the average rating was 5.9 and no student gave a rating lower than 4. On the same scale, but for the item about how enjoyable the workshops were compared to other training activities, the average rating was 6.0 and no student gave a rating lower than 4.





Students were asked what they would have liked to use extra time for in Session #2, if it had been available, and five said they would have liked more interaction with other REU students or hearing more about other presentations. Two responded that they would have liked more practice or to have given their presentation again to another group. One student each said an interactive activity, more on elevator talks, hearing the results of the projects, discussing good presentation formats, seeing more presentations, and question and answer sessions. One student said that more time was not needed, and eight students did not respond.

Students were asked that same question with regard to Session #1. Five said that they would have liked more PowerPoint specific advice and tips, two wanted more time with other REU students. One student each said more general tips, presentations, small group peer presentations, and talking practice. One students said that more time was not needed, and ten students did not respond.

The final Session #2 Post-Survey question invited students to make any other comments they wished. Ten students responded, eight of them offering positive comments about their experiences at the workshops. One respondent suggested having the presentations at the Museum of Science, and a final

respondent said that a category between 'agree' and 'disagree' earlier in the survey would have been helpful.

5. Other Data Sources - As noted earlier in the Student Impressions section of the report, on the web-based survey 82% of students rated the Science Communication Workshops as excellent or good. That survey also asked students what comments or suggestions they had about the Science Communication Workshops. Of the eleven who responded, seven had positive remarks, stating that the workshops were great. One suggested having professors and researchers attend, one suggested more workshops, and another suggested adding more time for questions. One student stated that the workshops were not necessary, but that the practice was helpful.

The focus groups also asked about the Science Communication Workshops. Overall, participants stated that the workshops were helpful, and some said that they were the best part of the REU program. Some international students found the workshops helpful because their coursework in their home countries did not include how to present their work. Students commended the Museum of Science staff, who gave ample opportunities to practice and were "well organized and well trained." Students also enjoyed the opportunity to interact with students from other CHN campuses and see what they were working on. They suggested that including graduate students and faculty in the workshops would be helpful. The focus groups also included some dissenting voices, including one participant who thought that the workshops were "beating a dead horse," because he had already had several similar lessons and felt that it is not difficult to tell when a presentation is good or bad. Another participant said that while the workshop was helpful, he would have rather stayed in the lab working.

Finally, two emails sent to the Museum of Science program director, Carol Lynn Alpert, shed additional light on workshop's impacts. One email was from an NEU student who said that he had not realized he would learn so much from the workshops. He shared that his professors and peers commented on the drastic change in his presentation skills, and he thanked the Museum of Science for "constructing such an impactful program/workshop."

The second email came from one of the CHN associate directors, who wrote "The 11 REU participants at UML presented their research today. The presentations were very good. All students had excellent slides, good body language, and no unexplained jargon or filler words. Most also made good eye contact with audience for the entire presentation. Content of presentations was very good, with students clearly explaining the background and motivations for their projects, the approaches they used; and their results. The students and I used your evaluation sheet to provide feedback to the presenters. I want to thank you, Alex, and Katrine for another excellent REU workshop. The results really showed in the final presentations and the students' faculty advisors were pleased."

Conclusion

This report provides an evaluation of the CHN Research Experience for Undergraduates (REU) program which occurred during the summer of 2009. Twenty-three students who participated in the program at Northeastern University, the University of Massachusetts Lowell, and the University of New Hampshire completed surveys and focus groups to provide feedback on the REU program. Several key REU program stakeholders also completed phone interviews focused on the Science Communication Workshops offered to REU students at the Museum of Science.

About one third of participants were female, and 23% were minority students. Substantial majorities of participants reported that their participation in the program increased their interest in pursuing graduate studies related to nanotechnology, their interest in finding a career in research and manufacturing related to nanotechnology, and their awareness of broader societal implications of new technologies related to nanotechnology, and about half reported increased interest in finding a career in science education and/or engineering education. Most students also felt more prepared to pursue careers in research and manufacturing related to nanotechnology.

In-depth assessment of the Science Communication Workshops offered by the Museum of Science included student surveys, student focus group questions, and phone interviews with key REU program stakeholders. The picture that emerged from these measures was very positive. Students rated the workshops as among the most helpful and enjoyable REU program activities, and their self-reported understanding of how to present their research to both scientific and non-scientific audiences increased from 50% to 94% and 100% respectively. Findings from the phone interviews with key REU program stakeholders were similarly positive. Although they offered several suggestions for next year's workshops, they felt that the 2009 workshops were very valuable for developing the REU students' science communication skills. The faculty wanted to offer similar workshops to graduate students and faculty in their departments, and they encouraged disseminating the workshops to other museum/university pairings in the NISE network.

When discussing strengths and challenges of the overall REU program, no single issue emerged as prominent across all students, but commonly noted strengths included the ability to do hands-on work and the Science Communication Workshops. Commonly noted challenges included issues of preparation, organization, accessibility of mentors and equipment, and obstacles to progress on research projects. Students' interactions with advisors were rated highly for the most part, although some dissatisfactions were expressed, and students' interactions with each other were rated very highly.

The overall summer research experience was rated as good or excellent by 95% of participating students. Faculty agreed that the 2009 CHN REU Program was a very positive experience that provided students with an opportunity to conduct hands-on research design, implementation, analysis, and reporting with the support of graduate students, postdoctoral fellows, professors, and outside experts.

Appendix A: REU Web-Based Survey

CHN's Research Experience for Undergraduates, Summer 2009

1. Institution and Respondent Description

Please answer the following demographic questions. NSF grant funding requires CHN to collect demographic information related to program participants. Thank you.

1. Please create your own identification number so we can match this survey with your previously completed survey.

The first letter of your first name (If your first name is Jane, write the letter J)

The second letter of your last name (If your last name is Doe, write the letter O)

The date of your birthday (If your birthday is May 3, write the number 3)

2. What university / college do you attend?

3. Where are you completing your REU?

- ◯ UNH
- ◯ UMass Lowell
- ◯ Northeastern University

4. Which of the following best describes your academic status?

- ◯ Completed Freshman Year
- ◯ Completed Sophomore Year
- ◯ Completed Junior Year
- ◯ Completed Senior Year

5. Please list your academic major(s).

6. What is your sex?

- ◯ Female
- ◯ Male

CHN's Research Experience for Undergraduates, Summer 2009

7. What is your race / ethnicity? (Please select all that apply.)

- ☐ African American / Black
- ☐ Asian
- ☐ Caucasian / White
- ☐ Hispanic / Latino(a)
- ☐ Native American / Alaska Native
- ☐ Pacific Islander
- ☐ Other (please specify)

8. What is your citizenship status?

- ◯ U.S. citizen
- ◯ Permanent resident
- ◯ Other non-U.S. (e.g., temporary visa; student visa)

9. Do you have one or more disabilities? (A disability refers to having an impairment that substantially affects one or more activities of daily living and is not correctable with assistive devices.)

- ◯ Yes
- ◯ No

CHN's Research Experience for Undergraduates, Summer 2009

7. What is your race / ethnicity? (Please select all that apply.)

- ☐ African American / Black
- ☐ Asian
- ☐ Caucasian / White
- ☐ Hispanic / Latino(a)
- ☐ Native American / Alaska Native
- ☐ Pacific Islander
- ☐ Other (please specify)

8. What is your citizenship status?

- ◯ U.S. citizen
- ◯ Permanent resident
- ◯ Other non-U.S. (e.g., temporary visa; student visa)

9. Do you have one or more disabilities? (A disability refers to having an impairment that substantially affects one or more activities of daily living and is not correctable with assistive devices.)

- ◯ Yes
- ◯ No

CHN's Research Experience for Undergraduates, Summer 2009

2. Participant Impressions

Please select the responses that most accurately reflect your opinion and answer open-ended questions as completely as possible. Thank you.

10. How has your ability level in each of the following areas changed as a result of your participation in the CHN summer research experience?

	Increased a Lot	Increased a Little	No Change	Decreased a Little	Decreased a Lot	N/A
(1) Find information using library database resources	◯	◯	◯	◯	◯	◯
(2) Condense literature search into a coherent written introduction	◯	◯	◯	◯	◯	◯
(3) Understand how a particular science or engineering challenge relates to a larger goal or application	◯	◯	◯	◯	◯	◯
(4) Construct a professional PowerPoint presentation	◯	◯	◯	◯	◯	◯
(5) Communicate a research project and results verbally as a 15-minute professional presentation	◯	◯	◯	◯	◯	◯
(6) Summarize the purpose and results of a research project in a brief 1-3 minute "elevator speech" to other researchers in the same field	◯	◯	◯	◯	◯	◯
(7) Summarize the purpose and results of a research project in a brief 1-3 minute "elevator speech" to people who don't have much scientific or technical training in your field	◯	◯	◯	◯	◯	◯
(8) Demonstrate new technical skills	◯	◯	◯	◯	◯	◯

11. How has your level of awareness, interest or preparation in each of the following changed due to your participation in the CHN summer research experience?

	Increased a Lot	Increased a Little	No Change	Decreased a Little	Decreased a Lot
(1) Awareness of the broader societal implications of new technologies related to nanotechnology	◯	◯	◯	◯	◯
(2) Interest in pursuing a graduate level degree related to nanotechnology	◯	◯	◯	◯	◯
(3) Interest in careers in research and manufacturing related to nanotechnology	◯	◯	◯	◯	◯
(4) Interest in careers in science education and/or engineering education	◯	◯	◯	◯	◯
(5) Preparation for careers in research and manufacturing related to nanotechnology	◯	◯	◯	◯	◯

CHN's Research Experience for Undergraduates, Summer 2009

12. How did you learn about CHN's Research Experience for Undergraduates program? (Please select all that apply.)

- [ ] Advisor recommended
- [ ] Faculty member (not advisor)
- [ ] Friend
- [ ] CHN Web site
- [ ] Received information via email
- [ ] Attended a workshop
- [ ] Was invited to attend (please specify by whom in the 'other' space below)
- [ ] Other (please specify)

13. Within the first week, my advisor and I developed a clear set of research goals related to my summer research experience.

- ◯ Strongly Agree
- ◯ Somewhat Agree
- ◯ Neither Agree nor Disagree
- ◯ Somewhat Disagree
- ◯ Strongly Disagree

14. I was given access to appropriate information, equipment, and facilities so that I could achieve my research goals.

- ◯ Strongly Agree
- ◯ Somewhat Agree
- ◯ Neither Agree nor Disagree
- ◯ Somewhat Disagree
- ◯ Strongly Disagree

15. Whom would you identify as the primary advisor for your research project?

- ◯ The professor with whom you worked
- ◯ The post-doctoral fellow with whom you worked
- ◯ The graduate student with whom you worked

CHN's Research Experience for Undergraduates, Summer 2009

16. My research advisor provided helpful guidance as my research project advanced.

- ◯ Strongly Agree
- ◯ Somewhat Agree
- ◯ Neither Agree nor Disagree
- ◯ Somewhat Disagree
- ◯ Strongly Disagree

17. What were the most significant strengths of this summer's REU program?

18. What were the most significant weaknesses of this summer's REU program?

19. What recommendations (if any) do you have for program improvement?

20. How would you rate each of the following aspects of your summer research experience?

	Excellent	Good	Fair	Poor	N/A
(1) Interaction with your advisor	◯	◯	◯	◯	◯
(2) Interactions with other students	◯	◯	◯	◯	◯
(3) Interactions with other professors	◯	◯	◯	◯	◯
(4) Opportunities to use research facilities and learn new techniques	◯	◯	◯	◯	◯
(5) Opportunities to share and discuss your research results with others	◯	◯	◯	◯	◯
(6) Housing	◯	◯	◯	◯	◯
(7) The two Museum of Science workshop sessions on science communication.	◯	◯	◯	◯	◯
(7) Overall summer research experience	◯	◯	◯	◯	◯

CHN's Research Experience for Undergraduates, Summer 2009

21. What are you plans after graduation?

- [ ] Pursue a Masters Degree
- [ ] Pursue a Doctoral Degree
- [ ] Find full-time employment related to STEM (Science, Technology, Engineering, Math)
- [ ] Find full-time employment in STEM teaching or education
- [ ] Find full-time employment NOT related to STEM
- [ ] Don't know
- [ ] Other (please specify)

22. What impact, if any, did this summer research experience have on you (e.g., academically, career plans, new collaborations, future research ideas)?

23. What comments or suggestions (if any) do you have about the Museum of Science Communication Workshop sessions?

24. Any other comments.

Thank you for completing this survey!!

The questions below are supplemental questions for UNH only.

(Focus groups were conducted with students from UML and NEU, but not with students from UNH due to scheduling constraints. To elicit comparable information from the UNH students, these additional open-ended items were added to their version of the web-based survey.)

22. What did you like most about the REU program?

23. What did you find most challenging or frustrating about the REUs?

24. What comments or suggestions (if any) do you have about the Museum of Science Communication Workshop sessions?

25. What advice do you have for students coming into the REU program next year? What do you wish you had known when entering the program?

26. What impact, if any, did this summer research experience have on you (e.g., academically, career plans, new collaborations, future research ideas)?

27. Any other comments.

Thank you for completing this survey!!

Appendix B: REU Focus Group Questions

1. What did you like most about the REU program?
2. What did you find most challenging or frustrating about the REUs?
3. If you were in charge of this program, what would you change?
4. How has the REU program influenced your desire to do research or not?
5. How has the REU program influenced your career/research plans for the future?
6. What advice do you have for students coming into the REU program next year? What do you wish you had known?
7. If you were to give an award to the REU program, what would it be for?
8. Now I would like to ask you about some of the specific program activities -- how they contributed to your experience this summer, how they were beneficial as well as any suggestions for change or improvement in the future:

    a. The two Museum of Science Communication Workshops.
    b. The Ethics in Nanotechnology session with Dr. Sandler.
    c. The Writing an Introduction session with Dr. Smyser.
    d. The (more-or-less) weekly meetings.

9. Any other thoughts or comments you would like to share about the program?

Appendix C: Science Communication Workshop Key Stakeholder Interview

Key Stakeholder Interview -- REU Program 2009
Science Communication Workshops at the Museum of Science

Note: Different questions were asked of different respondents, depending on their role in the program. Full names and roles of each respondent are described in the main report.

[Barry, Isaacs, Miller, Free, Hollar, Busnaina, Westervelt]

- In what ways did you hope the Museum of Science Communication Workshops would benefit the students?
- In what ways do you feel that acquisition of good science communication skills is important to the success of young people's careers in science?
    - Probe: Would you say that this a neglected area of science training?
    - Probe: Is there anything about nanotechnology, compared to other areas of science and engineering, that makes it particularly important to be able to communicate with scientists in other disciplines?
- In what ways does offering students this kind of science communication training benefit your faculty, your Center or department, and your university?
- What added value do you feel the Museum involvement in the training has beyond what is already provided by university faculty and staff?
- [Busnaina and Westervelt] Any other comments you'd like to make?

[Barry, Isaacs, Miller, Free, Hollar]

Now I'd like to ask you about some specifics of this summer's workshops.

- From a faculty standpoint, what did you find most valuable about the MOS set of workshops?
- How could the workshops have been modified to better meet your needs or your student's needs? (probe both for curricula and organization)
- Please compare this year's workshops with ones given in the past. In what ways were this year's workshops an improvement or were their aspects left out from the past that you'd like to see reinstated?
- Any other comments you'd like to make?

[Barry, Isaacs, Miller, Free, Hollar, Busnaina, Westervelt]

Now announce that I'm turning off the recorder, and then ask the next two questions. :

- Is there anything further you'd like to say about how the workshops could have been modified to better meet your needs or your students' needs?
- How responsive was the MOS team to your needs?
- Any other comments you'd like to make?

[Alpert, Fiorentino, Thate]

We'd like to understand how you think the curricula and organization of the REU Science Communication Workshops could be improved.

- What seemed to work best?
- What seemed to turn out worse than expected?
- What do you want to modify for next year?
- What additional help do you need from faculty?

Appendix D: Science Communication Workshop Surveys

Science Communication Workshop Session #1 Pre-Survey

Help the Museum of Science improve future workshops by providing us with feedback.

Sex:
❑ Male
❑ Female

Education:
(Check the year of college you will enter in the Fall)
❑ Freshman
❑ Sophomore
❑ Junior
❑ Senior
❑ N/A

Race/Ethnicity:
(Check all that apply)
❑ African American
❑ American Indian/Alaskan Native
❑ Asian-American
❑ Hispanic/Latino
❑ White, not of Hispanic origin
❑ Other: _____

Disabilities:
Temporary or Permanent
(Check all that apply)
❑ None
❑ Mobility
❑ Cognitive
❑ Visual
❑ Auditory
❑ Learning
❑ Other: _____

Since starting high school, how often have you…

	Never	1-3 times	4-5 times	More than 5 times
Given a talk on a science topic in front of a class or group.	❑	❑	❑	❑
Given a talk on a non-science topic in front of a class or group.	❑	❑	❑	❑
Used PowerPoint to present to a class or other group (science or non-science topics).	❑	❑	❑	❑
Participated in a course or workshop about science communication or public speaking.	❑	❑	❑	❑

Rate your agreement with the following statements:

	Strongly Disagree	Disagree	Agree	Strongly Agree
Improving my science communication skills is a high priority for me.	❑	❑	❑	❑
I feel confident speaking in front of an audience.	❑	❑	❑	❑
I have a good understanding of how to present my research to science audiences.				
I have a good understanding of how to present my research to non-science audiences.	❑	❑	❑	❑
I have a clear understanding of one or more potential applications of the research I am doing this summer.	❑	❑	❑	❑

What aspects of presenting science to an audience do you like the most?

What aspects of presenting science to an audience do you like the least?

How would you briefly describe the research project you are working on this summer to a friend who does not have a strong science background?

Please create your own identification number so we can match this survey with one you will complete at the end of the workshop.

_____ The first letter of your first name (Example: If your first name is Jane, write the letter J)
_____ The second letter of your last name (Example: If your last name is Doe, write the letter O)
_____ The date of your birthday (Example: If your birthday is May 3, write the number 3)

Science Communication Workshop Session #1 Feedback

Help the Museum of Science improve future workshops by providing us with feedback.

How useful to you were the following elements of today's session?

	Not at all Useful	Not very Useful	Somewhat Useful	Very Useful	N/A
Meeting other REU students	❑	❑	❑	❑	❑
Meeting other CHN faculty	❑	❑	❑	❑	❑
Getting a chance to see the Museum of Science	❑	❑	❑	❑	❑
Intro to science communication talk	❑	❑	❑	❑	❑
Good/bad presentation demonstration	❑	❑	❑	❑	❑
Voice and speech exercises	❑	❑	❑	❑	❑
Introduction exercise	❑	❑	❑	❑	❑
Context and meaning talk	❑	❑	❑	❑	❑
Context and meaning exercise	❑	❑	❑	❑	❑
Hand – outs	❑	❑	❑	❑	❑

What was most useful about today's session?

What information or topics were not presented today that you hope will be discussed during the next Museum of Science workshop session?

What other recommendations do you have for the next session?

Any other comments?

MOS Science Communication Workshop Session 2 Reflection

Please help the Museum of Science improve future workshops by providing us with feedback.

Welcome back!
Please rate your agreement with the following statements:

	Strongly Disagree	Disagree	Agree	Strongly Agree
I feel prepared to deliver 5-10 minutes of my research presentation or poster talk today.	❑	❑	❑	❑
The last MOS session helped me to prepare for delivering this presentation.	❑	❑	❑	❑
The last MOS session helped me learn how to be more comfortable introducing myself and my research in a variety of casual situations.	❑	❑	❑	❑
The last MOS session helped me learn how to prepare to explain the broader context of my research to people who are not in my specific research area.	❑	❑	❑	❑
I found the assignment to practice asking more experienced researchers about the broader context of their research to be useful.	❑	❑	❑	❑
Since the last MOS session, I have become more observant of the way people deliver research presentations and what makes some of them more successful than others.	❑	❑	❑	❑

Since the last MOS workshop session: Circle One

Did you use the "Poser Session Field Guide" one or more times? **Yes** **No**

Did you use the "Presentation Reflection Sheet" one or more times? **Yes** **No**

Did you use the "Presentation Reflection Sheet" to help you prepare for your presentation? **Yes** **No**

Did you practice giving today's presentation in advance? **Yes** **No**

If yes,

How often did you practice saying it silently to yourself?
not at all - once - a few times - many times

How often did you practice saying it aloud to yourself?
not at all - once - a few times - many times

How often did you practice giving it to one or more others?
not at all - once - a few times - many times

To how many people did you practice giving short introductions of yourself and your work (elevator speeches) since the last MOS workshop session: (circle one):

(no one) (myself) (1-3 others) (4-6 others) (7-10 others) (More than 10 others)

Please mention two or three insights you've had during the past few weeks about the challenge of communicating science clearly to people outside your field:

Now that you've completed your research project, how would you describe it in just a few sentences, to a friend who does not have a strong science background?

Please circle the university you attended this summer:

Northeastern University UMass-Lowell University of New Hampshire

Please create your own identification number so we can match this survey with one you will complete at the end of the workshop.

_____ The first letter of your first name (Example: If your first name is Jane, write the letter J)
_____ The second letter of your last name (Example: If your last name is Doe, write the letter O)
_____ The date of your birthday (Example: If your birthday is May 3, write the number 3)

Science Communication Workshop Session #2 Feedback

Help the Museum of Science improve future workshops by providing us with feedback.

Please rate your level of agreement with each of the following statements:

	Strongly Disagree	Disagree	Agree	Strongly Agree
Improving my science communication skills is a high priority for me.	❑	❑	❑	❑
I feel confident speaking in front of an audience.	❑	❑	❑	❑
I have a good understanding of how to present my research to **science** audiences.	❑	❑	❑	❑
I have a good understanding of how to present my research to **non-science** audiences.	❑	❑	❑	❑
I have a clear understanding of one or more potential applications of the research I am doing this summer.	❑	❑	❑	❑

Which small group did you participate in today? (circle one) 1 2 3 4

How useful to you were each of the following aspects of today's session?

	Not at all Useful	Not Very Useful	Somewhat Useful	Very Useful
Hearing from other REU students	❑	❑	❑	❑
Opening discussion and debrief on assignments	❑	❑	❑	❑
Warm-up "elevator talk" exercise	❑	❑	❑	❑
Small group work on presentations	❑	❑	❑	❑
Practicing giving my presentation to others	❑	❑	❑	❑
The feedback from my peers	❑	❑	❑	❑
The feedback from workshop leaders & faculty	❑	❑	❑	❑
The opportunity to see other presentations and give helpful feedback to my peers	❑	❑	❑	❑
The Presentation Reflection Sheets	❑	❑	❑	❑
Today's workshop session overall	❑	❑	❑	❑
Both MOS workshop sessions overall	❑	❑	❑	❑

What was most useful about today's session? Feel free to mention more than one thing.

What would you like more help with in the future regarding presenting your work?

What advice do you have for improving this Science Communication Workshop session or the pair of Science Communication Workshop sessions?

How did this pair of workshops rate compared to other training activities you took part in this summer? **(circle one on each row)**

One of the least helpful						One of the most helpful
1	**2**	**3**	**4**	**5**	**6**	**7**

One of the least enjoyable						One of the most enjoyable
1	**2**	**3**	**4**	**5**	**6**	**7**

Any other comments?

Please circle the university you attended this summer:

Northeastern University UMass-Lowell University of New Hampshire

Please create your own identification number so we can match this survey with one you will complete at the end of the workshop.

_____ The first letter of your first name (Example: If your first name is Jane, write the letter J)
_____ The second letter of your last name (Example: If your last name is Doe, write the letter O)
_____ The date of your birthday (Example: If your birthday is May 3, write the number 3)

Thank you!