A Mentoring Workshop for an REU Program

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Alpert founded the Presentation Rx Clinic for meeting speakers and moderators at the AAAS Annual Meeting, and her group coordinates a multi-university network of providers of two professional development courses they created: the REU Science Communication Workshop, and the Sharing Science Workshop & Practicum for university researchers.

Alpert has written and presented widely on forging museum/research-center partnerships, on interpreting current science in museums, coaching researchers in science communication, engaging public audiences in nanotechnology, and engaging stakeholders in nano-EHS risk communications. The MOS Strategic Projects Group produces professional development workshops in science communication and mentoring skills, as well as a variety of informal science education programs on current research in physics, chemistry, biology, and medicine. These include public presentations, hands-on inquiry-based learning experiences, science theatre, films, podcasts, and displays. The 2009 dramatic production, The Amazing Nano Brothers Juggling Show, has been seen by over 90,000 people at museums, schools, and science festivals, and was cited in the recent (2016) National Academy publication, Effective Chemistry Communication in Informal Environments. The NanoNerds YouTube channel has over 1700 subscribers. The Talking Nano DVD collection has been distributed to over 1300 high schools and museums. More than 95,000 people have attended the group's Museum presentations on current research. Alpert's 2012 film, Inventeens: a High School Engineering Challenge, produced in collaboration with Lawrence Klein, earned Golden Cine and Silver Telly awards. The companion film, Hands-on, Minds-on: Bringing Engineering Design to High School Classrooms earned a Bronze Telly. From Lab to Fab: Pioneers in Nanomanufacturing is the group's latest and most significant film project to date, with over 16,000 views online.

Alpert studied biology and history at Harvard and graduated magna cum laude and Phi Beta Kappa with a thesis in the History of Science. She produced exhibit films for the American Museum of Natural History and PBS science and history television documentaries for about 15 years, working with the NOVA Science Unit, The American Experience, Frontline, La Plaza, and with several multi-part international co-productions. Alpert also edited the New York Times best-seller, The Art of Possibility, by Rosamund Zander and Ben Zander. She joined the Museum of Science in 1999 to build the Current Science & Technology Center, recipient of the 2002 DOE-NIST "50 Best Practices in Communicating Science and Technology" award and the 2002 American Association of Museums Gold MUSE award for "Highest Standards of Excellence in the Use of Media & Technology for Interpretation & Education in Science." (submitted Feb 2017)

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Abstract

A Research Experiences for Undergraduate (REU) program provided students from local community colleges with a 10-week-long summer research experience at the University of Massachusetts Lowell. Each REU participant was assigned a research project, a faculty advisor, and a graduate student mentor. Few of the advisors and mentors had prior experience working with community college students, and few had received formal training in mentoring at all. In response, the REU director and a team of professional development specialists at the Museum of Science Boston designed a new approach to the typical REU mentoring workshop. This new workshop combined traditional mentor training content and approaches with some new content and approaches designed to 1) draw on the foundational experiences of the mentors themselves; 2) help them develop special sensitivity to dealing with the potential needs of a community college cohort; 3) stimulate the development of a peer-learning community for continued improvement in mentorship practices; and 4) place special emphasis on the importance of science communication training for mentors and mentees alike. Because of time constraints, the workshop was designed to fit into a four-hour session, including lunch. The mentoring workshop was attended by all graduate student mentors and several faculty members. Informal discussions with the participants and a post-workshop evaluation showed that faculty and graduate student participants found the workshop enjoyable and provided valuable insights and outcomes; this view was also shared by graduate students with prior experience mentoring undergraduate researchers. This paper provides details on the content of the workshop, its evaluation, and changes being made for the next mentoring workshop.

Introduction

Mentoring provided to undergraduate research students by faculty, post-doctoral researchers, graduate students, and industry professionals has been shown to increase their understanding of the technical field and to increase their ability to apply their knowledge to specific problems. Russell et al.[1] found that with mentoring, 88% of undergraduate researchers felt that they were better able to perform research projects and 83% reported greater confidence in research skills such as performing literature searches, designing and executing experiments, and analyzing research results. Undergraduate students exhibited greater ownership of design projects, capstone projects, and senior-level research projects, after participating in industrial cooperative work experiences (which require that the company assign a mentor to the student).[2] Mentoring also improves retention,[3,4,5,6] facilitates exploration of career options[7], increases participation in undergraduate research and cooperative work experiences[2], and leads to greater consideration of graduate programs[3,4,6,8,9] by women, underrepresented minorities, and first-generation-to-college students.

Although the mentoring needs vary with the student,[4,10,11] the critical qualifications for mentors are 1) accessibility, 2) expertise in the technical field, 3) the ability to communicate the project's overall goals and specific plans, 4) the ability to guide the project, 5) "personal concern" for the mentee, and 6) approachability (friendliness).[4] The latter two factors provide the critical personal relationship between the mentor and undergraduate student.[12] This mentor-student

relationship improves project outcomes because the undergraduate student feels more comfortable asking for mentor feedback on project ideas, assistance with literature searches and research skills, analyzing project results, and suggestions for other experimental approaches. The mentor also supports the undergraduate researcher during group presentations, provides advice about school and career options, and can become a member of the mentee's professional network.

A successful mentor-mentee relationship has two aspects: 1) respect and trust between the mentor and undergraduate student and 2) a sharing of power over the project. For respect and trust, the mentor must communicate the importance of this relationship and the undergraduate student's work. The mentor should also be approachable, positive, and patient. Better results also occur when the mentor has informal conversations with the mentee and provides rapid feedback to student questions.[3] Mentors can share power by clearly delineating the student's work from the research being performed on the rest of the project, reminding the undergraduate student that the work is their own, and allowing students to try out new their ideas.[3,13,14] The mentor should also sponsor and advocate for the student during meetings with the research group and faculty advisor.

In many undergraduate research programs, graduate student mentors have greater contact with - and influence on - the undergraduate students than do the faculty advisors.[15,16] Successful graduate student mentors exhibit the same qualities as all mentors.[15,17] Mentoring guidelines are available[18,19], but few focus on graduate mentors or on mentoring community college students who typically are coming in with even less experience than 4-year college and university undergraduates. Fewer programs tackle the science communication and broader-context issues so important to successfully engaging undergraduate students, and still fewer draw on the goldmine that is the workshop participants' own personal insights, having once been mentees themselves. In one well-designed program, Fiegel et al.[20] trained graduate student mentors 1) in creating and refining learning outcomes, 2) in effective teaching methods such as learning styles and questioning techniques, 3) in project management, including communication styles, effective meetings, and stimulating effective feedback, and 4) in creating an environment of trust. The last element taught the mentors about open lines of communication, ownership of the mentoring program, and failures as learning opportunities. There also were regular meetings to discuss mentoring issues. Although the graduate student mentors were not surveyed, the undergraduate researchers agreed that there were "clearly communicated project goals, objectives, and tasks" (4.4/5.0), "useful and constructive feedback (4.0/5.0), and they also felt that they were respected by members of their research team (4.8/5.0). In a variation, Tsai et al.[21] created a training program which focused on good mentor qualities such as being available, approachable mentor, and "individually genuine" in their relationship with the mentee (rather than on producing research results); training materials included existing guidelines[9]. Of the eight mentors in this program, three provided the desired "coaching" mentoring which focused developing the research skills of inexperienced undergraduate researchers, whereas the other five provided "supervisory" mentoring continued to concentrate on obtaining technical (research) results from undergraduate researchers.

This paper focuses on the first implementation of a new mentor workshop designed to include desirable training practices from previous programs, but also to incorporate significant elements of trainee self-reflection and small-group sharing, as well as practice in communicating the

broader context and motivation of research. The workshop was designed and delivered in collaboration with higher-education science-communication and professional-development specialists based at Museum of Science Boston was conducted in a single four-hour session, lunch included. The participants were graduate students and some faculty advisors providing mentoring to local community college students during a 10-week-long summer Research Experience for Undergraduate (REU) program. This REU Site offers research opportunities in advanced materials and manufacturing as well as a professional development program that includes science communication and workplace skills. Each student was assigned a research project, a faculty advisor, and a graduate student mentor.

Content of the mentoring workshop

The graduate student mentors in the REU program reflected significant diversity. They were selected for their expertise in the technical field and their interest in working with undergraduate students. The new Communication Skills & Mentoring Workshop was designed to address other critical qualities of successful mentoring, such as 1) being accessible and approachable; 2) being sensitive to student needs and concerns; and 3) being able to guide the project and communicate project goals, objectives, and plans, as well as the broader context and motivation for the work. The four-hour-long workshop incorporated a working lunch. The morning period focused on guiding the participants into a deeper understanding 1) of the mentee experience by reflecting on and sharing their own prior experiences being mentored and 2) of what special needs students coming from community colleges might have. It was led by workshop co-designers and facilitators from the Museum of Science Boston.

Part 1: Reflection and discussion of the mentee experience

For Participants were led through exercises to reflect on their own good and not so good experiences being mentored as student researchers. Prompts for these exercises are listed in Table 1. The workshop participants reflected on responses to these prompts first individually, and then shared their experiences with two or three other mentors, at least one of whom had experienced being a minority student. A debrief discussion followed, guided the attendees in developing a group-generated list of the most helpful mentoring practices, and some to be avoided. In this way, the participants co-created a more grounded understanding of how to be a good mentor, and their conclusions aligned with the guidance typically dispensed in a more didactic fashion, including being accessible and approachable, sensitivity to student concerns, establishing clear expectations and project goals, exercising good listening and communication practices, and maintaining a friendly, but professional relationship.

Part 2: Special needs of community college students

Next, the participants were presented with the demographics of the participants in this REU program - i.e., 74% of students entering the community colleges come from low income families, while only about 40% of students starting at the University of Massachusetts Lowell come from low income families. The workshop participants then split into two self-governing small groups, each charged with brainstorming and coming up a set of concrete ideas for providing this special group of REU students the means and tools for developing the necessary confidence to succeed.

The two groups reassembled and shared their ideas. After this debrief, they were advised to use this collaborative problem-solving approach during the course of the REU program ahead, mentoring other mentors in their professional growth toward mentoring success; i.e., build a support group, informally share challenges and solutions, and consult other experienced mentors for advice. Participants were also provided with reinforcing hand-outs and lists of other resources.

Table 1: Reflection on Previous Experiences as Mentees

Exercise	Questions
1. Reflection on previous experiences as mentees 1	Where were you? Who was your mentor? How experienced were you at the time? What were your hopes and fears? What were you excited about? A little nervous about? Were the project goals and methods clear to you at first?
2. Reflection on previous experiences as mentees 2	What did your mentor do or not do to guide you and help you feel comfortable? Did you feel that your mentor took an interest in you and had time for you? How often did you meet? Did you feel you could ask questions? Were there times you felt lost? Who helped you out then? What qualities did you most appreciate about your mentor? What did he or she do that felt really helpful to you? What more do you wish your mentor had done or said at the time?
3. Reflection on previous experiences as mentees 3	How do you think your mentor felt about mentoring you? Was he or she nervous? Under pressure? What was going on in his or her life?

Part 3: Science communication guidelines and practice

The second half of the workshop, held after lunch, focused on the importance of developing strong science communication skills. This part of the program was designed 1) to benefit the graduate students and faculty participants themselves; 2) to prepare them for communicating to students the broader context and motivation of their particular research projects; and 3) to familiarize them with the science communication advice that the Museum of Science Boston team would soon be providing their undergraduate mentees.

Why science communication? The workshop participants were briefed on the goals and design of two REU Science Communication Workshops (SCW) that were to follow during the 10 weeks. The REU SCW program[22] was partly the result of a previous collaboration of the authors, and has been extensively evaluated and successfully disseminated over the preceding years.[23,24,25,26] The REU SCW goals include building student confidence in their ability to speak professionally about their research and to feel adept at communicating it to family members and friends who may not have much background in science. The idea is to help the students build their own personal support networks for their continued involvement in STEM training. Mentor

workshop participants were given a preview of several of the key elements of the REU SCW workshops and then led through some of the exercises.

The Science Communication Workshop had several elements. First, workshop participants previewed the seven-minute-long video "Undergraduate Students Unwittingly Subjected to World's Worst Research Presentation," [27] which is used in the REU SCW as an example of what not to do in communication research. After a quick debrief, they reviewed the guidance students would be given on current standards and recommendations for professional research slide and poster presentations. They also were briefed on the full professional development program that would be offered over the 10-week trajectory of the REU program and how they could support their mentees' learning of good science communication skills for research.

Second, workshop participants discussed strategies for 1) effectively discussing research and the broader impacts of the technologies with the new student researchers, 2) guiding undergraduates as independent researchers, and 3) communicating detailed explanations of new equipment, technical processes, etc.

Finally, the mentor trainees practiced communicating the broader impact of their own research projects. They were guided in drafting a short elevator-type speech. They practiced these several times in small groups with guidance on how to give each other constructive feedback in between. The exercises are listed in Table 2.

Table 2: Communicating Clear Project Goals

Exercise	Activity
4. Communicating clear project goals	Discussion of technical vs. public audiences
	Prepare for the conversation the overall goals of their research projects - i.e., 60-minute-long "elevator pitch" What's the opportunity you want to seize? Who is the target audience? What do you want to get out of it? What will you say in the 60 seconds you have?
	Present pitch to two other workshop participants
	Based on feedback, revise the elevator pitch
	Present the revised pitch to two different workshop participants

At the end of the workshop, participants were given mentoring hand-outs and resources.

Evaluating the First Implementation of the Mentoring Workshop

The Communication Skills & Mentoring Workshop was facilitated by the Museum of Science Boston team during the second week of the 2015 REU program. Participants included seven graduate students - one of whom had previously mentored undergraduate researchers - and three faculty advisors. Four graduate student mentors were unable to attend, three because of scheduling conflicts and one because the project and mentor was changed after the start of the REU program. The workshop was evaluated with 1) a post-mentor workshop survey administered immediately after the workshop and 2) the pre and post-program surveys of the

mentors by the REU program's external evaluator. The participants enjoyed the activities and even the faculty participants stayed for the entire day-long workshop.

Results of the mentoring workshop

Part 1: Post-workshop survey

Four of the ten attendees completed the post-workshop survey provided by the Museum of Science Boston. All four found the overall mentor workshop useful, and all four reported they were a more effective mentor this summer as a result of the workshop (2 = definitely; 2 = probably). As shown in Table 3, the most useful aspects of the workshops included:

- "Getting advice on effective mentoring strategies" and "Practicing communicating the broader context of my work," both of which were rated “Very Useful” by 100% of the respondents; and
- "Self-reflection on my experiences of being mentored," "Getting to know the other mentors," and "Getting a briefing on good presentation practices as they will be taught to the REU students," all of which were rated as quite useful (3 = “Very Useful”, 1 = “Moderately Useful”).

Other elements, including "Discussing mentoring experiences with others" and "Practice making brief elevator-speech introductions to my work" had overall rating of "Moderately Useful." There was limited open comment feedback, but one mentor suggested an improvement to the workshop would be to hold it a week or two earlier, before the students arrived.

Table 3: Results from Post-Workshop Survey

How Would You Rate	Not That Useful	Somewhat Useful	Moderately Useful	Very Useful
The mentor workshop?	--	--	75%	25%
Getting to know some of the other mentors in the program?	--	--	--	100%
Getting advice on effective mentoring strategies	--	--	--	100%
Self-reflection on my experiences of being mentored	--	--	25%	75%
Discussing mentoring experiences with others	--	25%	25%	50%
Practice communicating the broader context of my work	--	--	--	100%
Practice making brief elevator-speech introductions to my work	--	--	50%	50%
Getting a briefing on good presentation practices for REU students	--	--	25%	75%

Part 2: Pre and post-program survey of the REU mentors

REU program mentors also participated in a pre- and a post-program survey. The pre-survey contained 18 questions and was completed during the second week the REU program, whereas

the post-survey contained 17 questions and was completed after the end of the REU program. In total, nine mentors participated in surveys: eight mentors participated in the pre-survey and five in the post survey. Each participant had a unique survey code, and it was determined that four mentors participated in both surveys.

The demographics of the mentors participating in the REU program (and responding to the surveys) included eight males and one female; six aged 21-30, two aged 31-40, and one aged 41-50; and four white, three Hispanic, and two Asians. They were asked 22 questions related to their confidence in their abilities to help their mentees. The responses for these 22 questions were totaled to create one "Mentee Helping" variable with a maximum possible value of 110. The mean responses for the before and after values of this variable were then compared. The mentors' mean confidence in their ability to help the mentees increased from 81.86 (SE = 4.94) to 89.60 (SE = 5.13). The increase in the "Mentee Helping" variable indicates that mentors did experience increased confidence in their ability to help their mentees over the course of the program, although it is not statistically significant due to small sample size. Analyses of selected responses are being used to modify the Communication Skills & Mentoring Workshop.

Part 3: Pre and post REU student survey

The pre and post surveys of the undergraduate researchers in the REU program provided indirect indicators of improved mentorship. As shown in Table 4, the REU participants felt that their understanding of the "science of design and method" and their "general research skills" improved significantly; the pre-survey results had high standard deviations (SD) due to the inclusion of two separately-funded entering seniors in the REU program. The undergraduate researchers generally felt that they were full participants in the research teams (team membership) and had good leaders. By the end of the REU program, the undergraduate researchers indicated a stronger agreement with the importance of being a scientist and their chosen career path ("belong in science" and "identify as scientist").

Table 4: Selected Results from Surveys of Undergraduate Researchers

Question	Pre-survey		Post-survey	
How do you rank	Mean	SD	Mean	SD
Science of design and method	3.15	1.02	4.17	0.65
General research skills	3.47	0.75	4.44	0.28
Team membership	4.55	0.41	4.93	0.13
Good leader	4.13	0.63	4.60	0.55
Important to be scientist	3.88	0.71	4.90	0.22
Belong in science	4.19	0.72	5.00	0.00
Identify as scientist	4.04	0.92	4.80	0.45

1 = strongly disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree; 5 = strongly agree

Part 4: Pre and post REU science communication workshop (REU SCW) student survey

Thirteen students responded to a pre REU SCW workshop survey administered by the Museum of Science Boston and nine responded to the post REU SCW workshop survey. This set of surveys has been used over several years in the implementation of the REU SCW at 12

universities.[24,25] The 2015 REU cohort at the University of Massachusetts Lowell showed much stronger than average gains in certain categories that may reflect the impact of introducing their mentors to the elements of the REU SCW as an intrinsic aspect of their Mentoring Workshop. For instance, while 53.8% of students in the pre-survey rated the "importance of good communication skills to a successful career in science" as “high” and 38.5% rated it “very high,” after the final SCW workshop, 77.8% rated it as “very high” and 22.2% rated it as “high.” We suspect strong support and reinforcement from the mentors helped to account for this larger than average shift. In addition, 89% of the REU students said that their "ability to seek out and communicate the broader context and motivation for a research project" improved as a result of their participation in the workshop sessions. Also, 90% of the REU students said they are “more” or “much more” confident “in their ability to present their research.” All of the students followed the advice of the program to practice their final presentation “aloud in advance.” We intend to conduct a more systematic comparison of these data with those of the broader group of SCW REU attendees during the next implementation of this program.

Part 5: 2016 indicators

Although no mentoring workshop was provided in 2016, the graduate student mentors were surveyed at the end of the 2016 REU program to obtain feedback on how they felt about their students’ final presentations and the Science Communication Training the students received. The final survey question asked “What information would be most helpful to new mentors?” Four of the mentors in the 2016 REU program responded this question and gave responses that would help us plan next year’s mentor workshop. One mentor noted:

> *“The beginning is the hardest. Time will be lost because of the nature of the training process. But once the student is brought up to speed, it is worth every moment. The first 2 weeks will be stressful as deadlines still need to be met, but time is lost to training.”*

Another mentor said:

> *“Start with basic introduction what is the research about. Let them read online to make it more clear. Combine lab work and reading at the same time. It helps the student to stay in focus especially if the topic is totally new to him. Listen to the students. Motivate them. Explain them the logic behind things.”*

A third mentor wrote:

> *“I felt like I only got information from my REU student about the program. The program should give the mentors the same information as the students. We should receive the due dates and an understanding of what's expected and when, etc. Even that (proper) introduction would make a difference for new mentors.”*

These responses reinforce the value of a mentoring workshop at the start of the REU program to help make expectations and timing clear, and to get mentors on the same page with the mentees.

Improvements to future mentoring workshops

Timing has been one of the primary challenges in hosting the Communication Skills & Mentoring Workshop; because of administrative delays, it was held after the start of the 2015 summer REU program and could not be scheduled in summer 2016. In the next iteration, the workshop will be scheduled at least one to two weeks before the REU students arrive to better

prepare the mentors. Feedback from the 2015 Workshop and advice from the 2016 mentor survey will be shared. Moreover, the expectations and timing for both mentors and mentees will be communicated at the mentoring workshop to help get all parties aligned before students arrive.

Conclusions

In collaboration with the REU Site Director, a customized Communication Skills & Mentoring Workshop was designed by a science educators from Museum of Science Boston. It was provided to graduate student mentors and faculty advisors mentoring undergraduates from local community colleges in a university-based REU program. The Workshop combined traditional mentor training approaches with some new approaches designed 1) to draw on the foundational experiences of the mentors themselves; 2) to help them develop special sensitivity to the potential needs of a community college cohort; 3) to stimulate the development of a peer-learning community for continued improvement in mentorship practices; and 4) to place special emphasis on the importance of science communication training for mentors and mentees alike. Informal discussions with the participants and a post-workshop evaluation showed that the faculty and graduate students found that the workshop was enjoyable and provided valuable insights; this view was even shared by graduate students who previously had mentored undergraduate researchers. Mentor evaluations showed that most of the workshop components were useful and later surveys provided suggestions for improving the mentoring experience within this REU program. Surveys of the undergraduate researchers showed improved research and communication skills, acceptance as full members of the research teams, and greater connections with their chosen career paths, all of which suggest better mentoring during the REU program.

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