PURM
Perspectives on Undergraduate Research & Mentoring

Development and Implementation of an Effective Graduate Student Mentoring Program in Support of Undergraduate Research Experiences

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Mentoring has been investigated widely both at the undergraduate level and graduate levels as a mechanism to promote professional development and to support women and underrepresented minority students in STEM disciplines and related fields (Conrad, Canetto, MacPhee, & Farro, 2009). In recent years, some studies have advocated the use of mentoring to support undergraduate research programs such as the National Science Foundation Research Experiences for Undergraduates (NSF-REU) programs (Carsrud, 1984; Dooley, Mahon, & Oshiro, 2004; Horowitz & Christopher, 2013; Jordan & Brooks, 2013; Ngassa, 2013; Raman, Geisinger, Kemis, & de la Mora, 2016). A significant number of studies in a wide array of STEM and STEM-related disciplines have demonstrated that mentoring efforts involving graduate students as mentors and undergraduate researchers as protégés[1] appear to benefit both the mentors and their protégés (Abbott-Anderson, Gilmore-Bykovskyi, & Lyles, 2016; Carsrud, 1984; Dooley et al., 2004; Horowitz & Christopher, 2013; Kiersma et al., 2012; Merolla & Serpe, 2013; Pfund, Pribbenow, Branchaw, Lauffer, & Handelsman, 2006). Benefits to the undergraduates include increasing their science identity salience, motivation, and their interest in postgraduate study (Haeger & Fresquez, 2016). Mentors also benefit from increased knowledge, productivity, self-confidence, and the development of mentoring, management, and leadership skills (Dolan & Johnson, 2009; Jordan & Brooks, 2013).

Dolan and Johnson (2009; 2010) have identified five tensions intrinsic to research universities that affect all shareholders – faculty, graduate/postdoctoral mentors, and undergraduate protégés- involved in the undergraduate research enterprise. These challenges have been recognized by others as well (Behar-Horenstein, Roberts, & Dix, 2010; Carsrud, 1984; Jordan & Brooks, 2013). Using graduate students as mentors can present challenges because of the graduate students' inexperience with mentoring, lack of self-confidence or overconfidence, weak communications skills, and unrealistic expectations (Abbott-Anderson et al., 2016; Dolan & Johnson, 2010; Jordan & Brooks, 2013). Faculty and graduate students are often focused on time limitations and the need for all research team members to be productive. In this environment, undergraduate research

[1] The choice and use of the word "protégé" as versus "mentee" throughout this paper is both intentional and philosophical. I see "mentee" as a passive term that implies the undergraduate is a needy juvenile who must be molded by their mentor into someone in the mentor's image. The term "protégé" on the other hand, carries with it respect for the undergraduate as a talented individual with prior knowledge and experience, which, while it may be limited, is valuable and has the potential to impact and inform their research project. So, the fundamental nature of the mentor-protégé and mentor-mentee relationship are, in my view, quite different.

experiences may not be viewed as valuable by faculty who believe that they may not be recognized or rewarded for their efforts to engage undergraduates in research.

The authors of several studies have concluded that mentoring is challenging and that graduate students need to be taught in order to be effective mentors (e.g., Abbott-Anderson et al., 2016; Raman et al., 2016). While some mentoring programs have been reported that do not appear to include any formal training for the graduate mentor, (Abbott-Anderson et al., 2016; Dooley et al., 2004) most mentor training programs include a significant commitment by the graduate student to the training program by participation in coursework, workshops, *etc.* for an extended time frame which varies from one semester to one year in duration (Abbott-Anderson et al., 2016; Horowitz & Christopher, 2013; Jordan & Brooks, 2013; Pfund et al., 2006).

One of the most well-known and most highly emulated of the formal graduate student mentor training programs is the Wisconsin Mentoring Seminar, developed by Jo Handlesman, Christine Pfund, Sarah Miller Lauffer, and Christine Maidl Pribbenow (Handelsman, Pfund, Lauffer, & Pribbenow, 2005; Pfund, Branchaw, & Handelsman, 2015). *Entering mentoring* outlines the mentoring curriculum for the eight-session, ten-week long seminar in the biosciences. Nine discipline-specific versions have since been developed for other disciplines including the physical sciences, engineering, and psychology. *Entering mentoring* is focused on providing training in the intellectual, technical, personal growth, and interpersonal issues relevant to the design and accomplishment of an undergraduate research project. Weekly sessions are discussions centered around case studies.

We know what characteristics promote the highest learning gains for undergraduate researchers from the literature on undergraduate research and the mentoring literature. These traits include trust and mutual respect, availability, providing timely feedback on research progress, helping protégés see “the big picture,” and moving protégés to autonomy in the laboratory (Lopatto, 2004, 2007; Seymour, Hunter, Laursen, & DeAntoni, 2004; Thiry, Laursen, & Hunter, 2011). Eby and colleagues argued for the importance of these traits in positive mentoring experiences in organizational mentoring (Eby & Allen, 2002; Eby, Butts, Lockwood, & Simon, 2004; Eby & McManus, 2004; Eby, McManus, Simon, & Russell, 2000). There is also strong evidence that supports the importance of educating mentors about the unique needs of underrepresented minority students (Lewis et al., 2017).

It is difficult to draw comparisons from the literature regarding the relative efficacy of the various approaches that faculty have taken to the design and implementation of graduate student mentoring programs for undergraduate research. There is no standard assessment instrument that has been used to evaluate undergraduate research mentoring programs. Most programs develop their own in-house surveys for which there is no or little evidence supporting instrument validity and reliability though there have been several very recent efforts to develop useful instruments (Ahn & Cox, 2016; Pfund, Byars-Winston, Branchaw, Hurtado, & Eagan, 2016). Furthermore, most studies of graduate student mentoring programs report only the positive outcomes. These factors make it very difficult to compare different programs and determine what factors are the most critical to program design. Indeed, it is difficult to conclude based on the available evidence that there is any benefit to requiring graduate students to participate in more intensive (time and topical coverage) training efforts.

This led me to wonder whether mentor training in undergraduate research had to be formal, time intensive, and exhaustive in topical coverage or whether all shareholders might be better served by a training program that was less intrusive of the graduate student mentor’s time and which focused on

developing positive mentoring traits promoting the known benefits of undergraduate research. I reasoned that if the mentor training program I developed were successful, it would represent a practical and unique model for intentional graduate student mentor training at research universities that might be attractive on a much wider scale than has been realized to date using approaches like the *Entering mentoring* curricular model (Handelsman et al., 2005; Pfund et al., 2015). The purpose of this paper is to describe the mentor training program and share some preliminary evidence supporting the efficacy of this model in providing both undergraduate and graduate students with positive mentoring experiences.

Research Methods

At the outset approval of this study was sought and obtained from the Northeastern University Institutional Review Board.

Description of the REU Program

The REU program, funded by the National Science Foundation, was based in the Department of Chemistry and Chemical Biology on the campus of a large private urban research university located in the Eastern United States. The goal of the REU program was the diversification of the talent pool in STEM by providing talented underrepresented minority students with knowledge and training in biological and chemical catalysis and first-hand knowledge and experience of graduate education at an urban research university. We targeted undergraduate participants with limited or no opportunities for participation in undergraduate research. Over the three year period that the REU program ran (2013-2016), a total of twenty-eight undergraduate students participated. The majority (61%) were female. Further, 46% of the participants were traditionally underrepresented minorities. A total of 2 Native American/Pacific Islanders, 6 Hispanic/Latino, 5 African-American, and 12 Caucasian students participated. These students came from 21 different academic institutions (all levels) in the U.S. and Puerto Rico. One REU student worked directly with her faculty advisor in a lab with no graduate students so this student did not participate in the mentoring program.

Each summer the students came to the university for a period of ten weeks running from the beginning of June through the beginning of August to work full-time for 40 hours each week in a research laboratory. Unique aspects of our program include the use of graduate students as mentors, research learning contracts (Mabrouk, 2003), and the development of student research portfolios as pedagogical supports. All students participated in a weekly professional development program (topics included Information Literacy & Literature Searching, Research Ethics, Resume Writing & Review, Giving an Effective Research Presentation, and Graduate School and the Application Process), attended a weekly colloquium series in which they and their faculty advisor presented on their group (research advisor) or their own (undergraduate student) research, went on field trips to companies, and delivered an oral presentation at a final research symposium. REU students who completed novel research were also offered the opportunity to present their original work to the greater scientific community of practice through the presentation of a poster or oral presentation at a relevant national technical conference such as the bi-annual National American Chemical Society Meetings or the American Society for Biochemistry and Molecular Biology annual meetings.

Mentoring Program

Role of the Faculty. By choice, the faculty did not have a formal and/or active role in the mentoring program beyond identifying a graduate student from their research group who would serve as a research mentor and participate in the mentor training program. None of the faculty expressed an

interest in participating in the development or execution of the mentor training program. It is possible that even though the faculty did not play an active role in the mentoring program that their views and values could have impacted the outcomes of the mentoring program however we do not have any evidence that the faculty had any direct impact.

Mentor Selection and Assignment. The idea was to leverage a more senior research group member so that the REU student would have someone "local" to whom they could reach out on a daily basis, if needed, with questions. Qualifications included a willingness to serve as a mentor, general technical knowledge concerning the REU student's research project, and strong experimental lab skills as peculiar to the REU student's project. Some faculty expressed concern that the mentoring program might distract their doctoral students from their primary objective of making good progress on their own research projects in the laboratory.

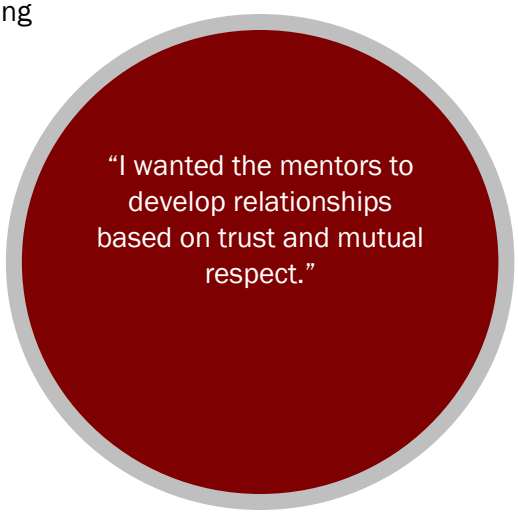
Same gender dyads have been shown to be associated with positive mentoring in the mentoring literature (Allen & Eby, 2004; Conrad et al., 2009; Koberg, Boss, & Goodman, 1998; Lockwood, 2006; Ragins & McFarlin, 1990; Scandura & Williams, 2001; Thomas, Hu, Gewin, Bingham, & Yanchus, 2005). It became clear quickly that imposing a same-gender requirement for mentor-protégé dyads was impractical in many cases because of the small size of many participating research groups, their gender make-up, and availability of graduate students interested in serving as an REU mentor. Thus, I encouraged faculty to identify graduate students of the same gender when possible. Over a three-year period, thirteen female and twelve male graduate students served as mentors. Each graduate student served as a mentor to one undergraduate student for a single REU program. Two graduate students (two Asian American male students) served twice as mentors during the first and third years of the REU mentoring program. Ultimately, over the three-year period that the REU ran, twelve of the twenty-seven REU students (44%) were successfully matched with mentors of the same gender.

Though I would have liked to have paired mentors and protégés by ethnicity as well as gender, it was clear that this would not be possible due to the lack of diversity in the available graduate student pool. Over the three year period, 52% of the mentors were White, 37% were Asian American, 7% were Black, and 4% were Hispanic/Latino. Indeed, in the end, only five pairs had mentors and protégés of the same ethnicity and four of these pairs were White and one pair was Asian American. Thus, it was not possible to investigate the association of ethnicity and positive mentoring.

The mentoring literature is silent on whether the year of a graduate student's study might positively or negatively impact the mentoring relationship. Therefore, no restrictions were placed on the graduate student's year of study. All of the mentors recruited were doctoral students who had been in the program for at least one to four years. The majority had completed their second (n = 9) or third year (n = 10) of graduate study. One graduate student who had completed one year of study participated in the mentoring program the first year of the REU program. In our doctoral program, students take coursework their first year, choose an advisor during the spring semester and then complete their qualifying exams during their first summer.

Mentoring Program Requirements. Graduate student mentors were required to participate in two one-and-a-half-hour long training sessions, complete a final survey and ask their protégé to a complete similar survey. To formally recognize and value the graduate student mentors, motivate them to attend both workshops, and encourage mentors to collect and submit the completed mentoring survey forms, I offered each mentor a $50-gift card. Cards were awarded upon submission of their and their protégés' final surveys at the end of the REU program.

The overarching goal for the mentoring program was to address the five tensions that Dolan and Johnson (2009, 2010) identified in their work to provide mentors with knowledge, resources, and practice focused on developing realistic expectations, strong communication skills and a healthy self-confidence in their mentoring abilities. I had several immediate objectives for the mentor training program based on what we have learned from studies of the benefits of undergraduate research (Adedokun, Bessenbacher, Parker, Kirkham, & Burgess, 2013; Lopatto, 2003, 2004, 2007; Seymour et al., 2004; Thiry et al., 2011). First, I wanted the graduate student mentors to help their REU students to see "the big picture" and understand how their individual research project fits into their advisor's research portfolio and how it knit into the fabric of the greater community of practice in STEM. I also wanted the mentors to develop relationships based on trust and mutual respect, to provide their students with support by being available and by providing their protégés with timely feedback on their research progress, and finally over the course of the summer to help their protégés become more independent. These are characteristics that have been shown to result in the highest learning gains in undergraduate researchers (Lopatto, 2004, 2007; Seymour et al., 2004; Thiry et al., 2011). A succinct description of each mentoring workshop follows.



Session 1. The first workshop was held two weeks prior to the start of the REU program. Upon arrival at the workshop, all graduate student mentors were provided a name tag, a five-dollar gift card for Dunkin Donuts, a blank 3" x 5" index card, and paper and electronic copies of the following materials: an individual mentoring plan (IMP) template; a series of reprints including one on Research Learning Contracts (RLC) (Mabrouk, 2003); a reprint entitled "Whitesides' group: Writing a paper" (Whitesides, 2004); an annotated version of a well written, highly-cited technical article (Hinsberg, Milby, & Zare, 1981); an article entitled "The archival journal article;" an RLC template; and a copy of the Powerpoint presentation for the workshop.

At the start of the workshop, I discussed the benefits of mentoring and the characteristics of an effective mentor based on the mentoring literature. Participants were encouraged to share with the group their past mentoring experiences and the characteristics they valued in their past and present mentors. Since many of the undergraduate participants in the REU program were underrepresented minority students and/or first generation college students, I then discussed the unique challenges and needs of these populations (Chemers, Zurbriggen, Syed, Goza, & Bearman, 2011; Conrad et al., 2009; Sharp, Kleiner, & Frechtling, 2000). The discussion then focused on best practices laid out within the framework of the REU program. I introduced the resources available to assist the mentors including the Web-based Guide to Undergraduate Research (WebGURU; Mabrouk, McIntyre, Virrankoski, & Jeliffe, 2007), a template for an individualized mentoring plan (IMP; see Appendix A), a template for a research learning contract (RLC; see Appendix B; Mabrouk, 2003), the mentor pre- and post-assessment tool (see Appendix C), the selected reprints mentioned above, their faculty advisors, the other graduate student mentors, and the workshop presenter. Mentors were encouraged to email their protégés before the start of the REU program to welcome them to Boston, introduce themselves as their mentors, and answer any questions their protégés might have. On the first day of the program, mentors were encouraged to meet with their protégé following the formal welcome program to discuss their research projects and ascertain their protégés' needs. The workshop participants were encouraged to use their 3x5" note cards and ask their participants to identify their "immediate, critical, and urgent" (ICU) needs.

Food is well known to promote social interaction (Rozin, 2005), trust, and cooperation (Maddux, Mullen, & Galinsky, 2008; Nicolaou et al., 2009). Very recently, Woolley and Fishbach (2017) showed that the act of sharing food, even when food selection is imposed externally, promotes trust and cooperation between the meal partakers. Coffee is readily available on college campuses and widely consumed by adults (over 20 years old) in the United States (Loftfield et al., 2016). So, all mentors were given a $5 Dunkin Donuts gift card as an incentive and to provide them with a mechanism with which to initiate an informal conversation and mentoring session. Here, they could begin to develop rapport and trust with their protégés.

Following a discussion of the coffee card incentive, we had a lively discussion around troubleshooting problems that was focused on identifying the relevant local experts and resources and discussing possible solutions. I then reviewed the program's expectations for the mentors and closed the session with an assessment of the workshop using the ICU technique and the note cards provided to the mentors. I used the cards to obtain feedback from the mentors on the session and also to model how the mentors might use 3x5" cards and the ICU technique to obtain feedback from their protégés on their concerns and needs. Many graduate student mentors identified learning about their student's background, identifying student's needs, and contacting their student as their immediate, critical, and urgent needs (see Table 1).

Session 2. The second session was held near the middle of the REU program. At the start of the workshop, mentors were provided with a model student resume, quick start sheet for Digication (e-portfolio platform), a 3" x 5" notecard, two envelopes, a copy of the mentor and the protégé exit surveys (see Appendices D and E), a worksheet on communications, an instrument to use in tracking the mentors' chosen student learning outcomes, and a copy of the Powerpoint presentation for the workshop.

In the second workshop, the goal was to do a mid-course progress check-in, review available resources, and to help the mentors to self-assess and self-correct as needed. I opened the second session with a brief discussion of anonymous and affirmative feedback derived from one-on-one interviews the workshop leader had conducted as part of the programmatic assessment with the REU students at the end of the first week of the summer REU program. The following quotation is an example of the kind of anonymized feedback I received and shared with the mentors corporately: "[Name] is doing a great job. [Name] is very supportive and patient with me. As the days go on in lab, I am getting more confident with what I am doing." Most of the time in the workshop was split between discussion of issues that mentors had faced to this point and a mock resume review. I used the mock resume review as an opportunity for mentors to practice providing their protégés helpful, critical feedback. The following are examples of some of the concerns that mentors raised for discussion: how to deal with a protégé who falls asleep in mid-conversation; and how to initiate a constructive conversation with a protégé who arrives late in the day, not appreciating how their tardiness impacts their mentor's schedule and responsibilities. Mentors were also provided with a 6-item mentor assessment tool that the mentors were encouraged to use to track their students' development (see Appendix C). The instrument was focused on the protégés' technical skill development and was intended to provide the mentors with an opportunity to self-assess their success in facilitating the development of their protégés' abilities as researchers. Lastly, I reviewed the assessment plan for the mentoring program with the mentors. Mentors were provided with a copy of both survey instruments: the survey for the protégés and the survey for the mentors. This way the mentors knew upfront what evaluation criteria were being used to evaluate their and the program's success.

At the close of the workshop, mentors were asked to use a notecard that was provided to jot down what they felt was most helpful about the session and one outstanding question (see Table 2). Many

mentors felt hearing from their peers was most helpful. One mentor wrote: “To hear other mentoring experiences and see how they compare. Know that we are all in this together.” Another amplified on this as follows: “Know other mentors’ situation and compare their experience with my experience. This makes me learn more about mentoring skills.” None of the mentors indicated that they were leaving the workshop with unanswered questions.

Assessment of the Mentoring Program

Mentors were given a $50 gift card as an incentive for completing and submitting the final mentor survey and their protégé’s completed protégé survey during the final week of the REU program. Mentors were provided with an envelope for both their and their protégé’s completed survey to ensure privacy/anonymity. Surveys were marked with a number so I could compare mentor-protégé responses pairwise. A total of twenty-seven mentor-protégé pairs returned useable surveys in all. The 100% response rate is high in part because the mentors were incentivized to collect, complete, and return their own and their protégés’ completed surveys.

Survey Instrument. Though graduate student mentoring programs in support of undergraduate research programs have been described in the literature, efforts to assess the effectiveness of these mentoring programs are often either simply not described or qualitative methodologies are employed. Some promising instruments probing mentor effectiveness in the biomedical sciences have recently been reported in the literature (Andrews & Chilton, 2000; Berk, Berg, Mortimer, Walton-Moss, & Yeo, 2005; Dilmore et al., 2010; Fleming et al., 2013; Handelsman et al., 2005). None of these instruments was ideal for this work. Several tools are intended for use in mentoring programs involving postgraduates working in academic medicine or clinical and translational science and focused on traits and characteristics more relevant to these career paths (Andrews & Chilton, 2000; Berk et al., 2005; Dilmore et al., 2010). The instrument used in *Entering mentoring* (Handelsman et al., 2005) was determined to be overly focused on the *Entering mentoring* curriculum and too lengthy based on the graduate student feedback I received. I also considered adopting the Mentoring Competency Assessment (MCA) inventory, which has been piloted nationally at 16 colleges and universities (Fleming et al., 2013). As I sought feedback on a different set of issues than were reflected in the MCA, specific to the undergraduate research experience, I decided in the end to use a hybrid instrument based on a tool developed in-house which had been used in an earlier study of a graduate student mentoring program (see Appendices D and E).

An initial set of 30 quantitative fixed scale (Likert) and qualitative (open-ended narrative) items was identified probing both the psychosocial and career-related aspects of the mentoring experience. As stated earlier, I wanted the graduate student mentors to help their protégés to see the big picture and gain perspective on how their research project fit into their advisor’s research portfolio and their discipline. I wanted the mentors to develop relationships based on trust and mutual respect, to provide their students with support through their time and by providing their protégés with timely feedback on their research, and finally over the course of the summer to help their protégés become more independent and self-confident. For this reason, I designed the instrument to evaluate how well we achieved these objectives. A mix of both positively and negatively worded items was included in the quantitative statements. After receiving feedback from graduate students serving as mentors in a college-wide undergraduate research program, some of the statements were revised for wording or eliminated. In the end, the final surveys consisted of a total of 18 (protégé)-19 (mentor) quantitative items and five qualitative questions probing the participants’ mentoring relationship from the perspective of the undergraduate protégé (see Appendices D and E). Demographic information including gender and ethnicity was neither directly solicited nor captured in the survey.

The students’ satisfaction with their mentor and their mentoring experience was probed through a series of Likert scale questions. The first question asked the participant to confirm their identity as

an undergraduate student or graduate student. The next two questions on both surveys examined the participant's perceptions regarding the time they spent with their mentor or protégé and the perceived adequacy of the time they spent working together. The next set consisted of twelve statements that probed the mentoring relationship from the perspective of the mentor and the protégé. Participants were asked to indicate their response using a four-point scale. Protégés were asked if they would recommend their mentors and mentors were asked if they thought their protégés would recommend them to another student researcher. Both mentors and protégés were asked about their prior experience with mentors. Mentors were asked about the adequacy of the mentoring training program.

Mentors and protégés experiences were also probed through a series of five open-ended narrative questions. My intent was to use the open-ended questions to allow participants to elaborate on their ratings in the quantitative section of the survey and ensure that I was correctly interpreting their responses. Protégés were asked:

- Would you recommend your mentor to another student researcher? Please explain your answer.
- What characteristics made your mentor effective?
- What characteristics could your mentor work on to become a more effective mentor?
- Please feel free to share here any other comments you would like to regarding your mentoring experience this summer.

Mentors were provided a parallel set of open-response questions:

- Do you think your protégé would recommend you as a mentor to another student researcher? Please explain your answer.
- What would you do differently if you were to mentor again?
- Are there any changes you would recommend in the mentoring training program for the future?
- Do you have any other comments you wish to share?

Analysis. Scaled survey data were analyzed using IBM SPSS Statistics v.24. With one exception (the Perspectives category for the mentor surveys), a one-way ANOVA was used to assess whether there were any statistically significant variations regarding satisfaction levels between the three cohorts (summer 2014, summer 2015, and summer 2016) for α=0.05. No statistically significant differences were observed between the three cohorts. The convergence supported analysis of the quantitative data in aggregate, so the analysis is based on the aggregated data for the three REU programs run from 2014 to 2016.

Results and Discussion

Limitations of the Study

This study examined a single REU program in the field of chemistry that took place on the campus of a large private research university in the Eastern United States. The REU program used a single approach to mentor training led by the same individual each year for three years. A small number, 54 in total, of graduate and undergraduate students were affected. Furthermore, the data came from a select group of high-achieving undergraduate students (average GPA 3.4) albeit from diverse backgrounds (ethnically, institution type, and geographically). As such this study's findings have limited statistical power. Lastly, this study did not include a control group as that would have been problematic for some reasons including beneficence and justice since this was an NSF-funded REU

program targeting underrepresented minority students (Lopatto, 2004, 2007; Thiry et al., 2011; Zydney, Bennett, Shahid, & Bauer, 2002).

Overall Mentor-Protégé Satisfaction with their Mentoring Experience

Mentors were explicitly asked if they thought the mentor training program had provided them with "adequate support and training." Twenty-six mentor respondents (96%) indicated that the program had provided them with adequate support and training. The one dissenting respondent indicated in the open text box "I missed both [mentoring] programs," acknowledging that they had not attended the two training workshops and thus had not participated in the mentor training program.

The protégés' satisfaction with the mentoring program was assessed in two ways. First, undergraduate research students were asked about their satisfaction on the final REU program exit survey. A modified version of the URSSA instrument was used in the programmatic assessment of the REU as this instrument is used by the NSF BIO REU programs (Weston & Laursen, 2015). On the URSSA survey, REU participants were asked to rate "How useful were the Graduate Student Mentors in helping you get the most out of the REU program." Responses were registered using a 5-point Likert scale in which "1" indicated "none" and "5" corresponded to "a great deal." The Graduate Student Mentors was consistently a highly ranked REU program activity (in 2014 and 2015, 4.4 ± 1.0 and 2016, 4.7 ± 0.8).

The protégés' willingness to endorse their mentors and the mentors' willingness to mentor another student again in the future were also used as indicators of the protégés' and mentors' satisfaction with their mentoring experience. The majority of protégé respondents (82%) indicated that they would recommend their mentor to another student researcher. The remainder (18%) were "uncertain" whether they would recommend their mentors. Nearly all the mentors (89%) indicated that they would mentor an undergraduate again in the future. Overall, both the mentors and protégés participating in this mentoring program appeared to be highly satisfied with their mentoring experiences.

Influence of Gender

As stated earlier, according to the mentoring literature, matching mentors and protégés by gender has been shown to promote positive mentoring (Allen & Eby, 2004; Conrad et al., 2009; Koberg et al., 1998; Lockwood, 2006; Ragins & McFarlin, 1990; Scandura & Williams, 2001; Thomas et al., 2005). We did not explicitly ask for demographic information on our survey instruments. However, we found that we could gain some insights into the role of gender based on the pronouns used in the students' responses on the open-ended questions. Based on this analysis, we found that three of the five protégés expressing dissatisfaction with their mentors were women in same-sex mentoring partnerships and none of these were males in a same-sex mentoring partnership. While the number of dissatisfied protégés in our study is quite small, the greater dissatisfaction I observed for women in same-sex mentoring partnerships does call into question whether there may be differences between the mentoring relationship in undergraduate research partnerships that make mentoring in same-sex partnerships unique. Clearly, this observation suggests the need for further work.

Prior Mentoring Experiences

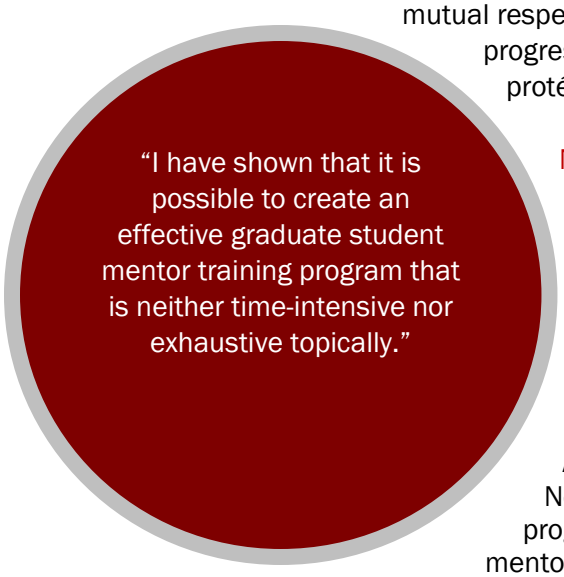
Eleven respondents (41%) indicated that they had previously participated in a "mentored" undergraduate research experience. Of these eleven students, six stated their experience with mentoring in the REU program was better than their prior experience. Three students stated that their mentoring experience was comparable. Two felt that their past experiences had been better and based their evaluation on the strength of the personal relationships they had developed with past mentors. One student wrote: "Past mentors might be the reason I expect higher standard. I still communicate with prior mentors who showed more interest in me." The other student wrote: "This

experience was very comparable, but I've been able to form stronger relationships with my other mentors." According to Mentoring Theory, mentoring relationships evolve and change over time (Chao, 1997; Kram, 1983, 1988). The developmental nature of mentoring has been largely ignored in the mentoring literature on undergraduate research, and this subject represents another important area for future study.

Discussion

In conclusion, I have shown that it is possible to create an effective graduate student mentor training program that is neither time-intensive nor exhaustive topically. This argument is supported by both the high level of satisfaction of the mentors and more importantly by the high degree of satisfaction of their protégés with their mentoring experience and is based on the analysis of data collected using two different survey instruments.

I believe that the success of this approach stems from the fact that mentor training was focused on developing those traits shown to promote positive mentoring relationships and the highest learning gains in undergraduate researchers. I would encourage faculty considering implementing the use of graduate student mentors in support of undergraduate research experiences to offer one or two short, focused training sessions for the graduate student mentors. These should provide mentors with support in those areas most likely to benefit undergraduate researchers such as trust and mutual respect, availability, providing timely feedback on research progress, helping protégés see "the big picture," and moving protégés to autonomy in the laboratory.



Next Steps

I am currently diving deeper into the mentoring survey data to identify those mentor traits which promote positive mentoring relationships in undergraduate research experiences. Insight into the mentor characteristics that promote gains in the personal and professional benefits of undergraduate research has the potential to improve and inform the practice of undergraduate research widely.

As stated earlier, this study has limited statistical power. Next steps include collecting data for a larger group of REU programs representing a more diverse and larger group of mentors and protégés working in different STEM disciplines at different colleges and universities to determine the generalizability of our findings. I also plan to probe mentoring in undergraduate research relationships where more senior undergraduates may act as research mentors.

Based on the feedback received from participating mentors and protégés, I plan to develop a web-based repository of resources in support of graduate students serving as undergraduate research mentors with specific content focused on areas where student mentors appear to need the most assistance, specifically, communications, mutual trust and respect, and how to deal with mismatches in protégé-mentor expectations concerning the mentoring relationship.

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Table 1

Immediate, Critical, and Urgent Takeaways from First Mentoring Workshop

Mentor	Immediate	Critical	Urgent
1	Discuss project ideas with research advisor for mentee and develop goals and a plan for the summer	Reach out to mentee to make them feel more welcome and comfortable coming to NEU & Boston ☺	Email address of mentee, personal statement/application of mentee
2	Getting to know the student	Understanding what is expected mutually between myself and the student	Program logistics – their expected hours, schedules, weekend activity, etc.
3	Contact the student before arrival	Ensure student's success in research and learning	Address any concerns from student (safety, understanding of project, etc.)
4	How many hours of work a week is expected of my student?	The importance of communication and understanding was well addressed and will be critical in my experience with my student	I need my students email/contact info. Also, I would really like to see their application material.
5	Be patient. Have good communication. Be prepared before mentoring. Know the student. Figure out their interest and find		

	the best way to work with them.		
6	Student's CV & background	Student's lab coat & goggles supplied by someone somehow	Overview how much the student knows about what about to happen in the next ten weeks
7	I need to meet with my research advisor and discuss what she expects from me as a mentee and us as a REU team	Background information on my mentee (academic, social, etc.)	I need to concentrate/take myself out of my research to focus on my REU's experience/project
8	Be confident and trust myself when talking with people; be positive	How to communicate with the students; to understand how people think, help the student to learn about chemistry culture	To know the student's background, be friendly to the student
	That my REU student will have very little biochemical and/or analytical background	That my REU student will not share her concerns/questions with me	That my student will not learn how to operate independently

Table 2

Most helpful Takeaways from Second Mentoring Session

Category	Comments
Hearing from Other Mentors	Know other mentors' situation and compare their experience with my experience. This makes me learn more about mentoring skills. Get some effective advices of solving my mentoring problem.
	I appreciated going through the resume, which is helpful to both my student and myself. I also liked going through our mentor problems/successes, discussing them and troubleshooting. Very helpful as a group.
	To hear other mentoring experiences and see how they compare. Know that we are all in this together. Also the resume talk was a good refresher.
Communications	Get to know your student more, their interest or motive behind this program
	How to engage the mentee more so than how has been happening. How to help with resume building.
	To be honest and open with my student, and do my best to help motivate him, but understand that he needs to take equal responsibility.
Other	Effectively critiquing student resumes. I think this is a good program.
	Helpful today: Support the students. Be patient and ask them. Resume review – how to write a good resume.
	Mentor expectation

Appendix A

Individual Mentoring Plan (IMP)

Mentor Name _____ Protégé Name_____

Date_____

Objective(s) *What do I want to accomplish? (SMART) Specific, measureable, achievable, realistic, time-related*	Activities *Methodology – What specific tasks will I undertake? What will I do to accomplish each objective?*	Skills (to acquire or use) and Resources Needed	Timeline *When will I do the activities in the second column*	Assessment *How will I know that I have accomplished my objective?*
Objective 1.				
Objective 2.				
Objective 3.				
Objective 4.				
Objective 5.				

Appendix B

Research Learning Contract Template

[Student's Name]
[Local Address]
[Cell phone]
[permanent email address]

[Research Advisor's Name]
[Office Address]
[Cell phone]
[email address]

[Peer Research Mentor's Name]
[Office Address]
[Cell phone]
[email address]

[Research Project Title; succinct 10-words or less]

Project Goal: [One sentence –long term; overall what does your Research Advisor hope to learn and/or achieve?]

Project Objective: [One sentence - short term; what does your Advisor want you to accomplish this summer?]

Methods/Techniques/Instrumentation: [this section should list the experimental or theoretical methods you will learn, the experimental or theoretical techniques you will master, and/or the analytical instrumentation you will use this summer in your project; useful content for your post-undergraduate research experience resume]

Project Outline: (add/subtract rows as needed)

What are you going to do?	What resources are required to do it?	How will you know that you did it?	What are you going to learn by doing it?	Target Date for Completion

Lab Safety: [What are the possible dangers to you and/or others that could result from your carrying out this project? What specific forms of training will you undertake in order to be prepared to deal with these potential problems? What specific protocols will you follow in order to ensure your and others safety?]

Confidentiality/Openness: [Can you speak freely with others about your work? If not, with whom can you speak?]

Data Management: [what data are you expected to record? Where are you expected to record it?]

Data Analysis: [how are data usually processed? analyzed? Under what circumstances under which data can be eliminated from a dataset?]

Authorship: [Are there any opportunities for publication or conference presentation that are likely to result from your summer work? If so, under what conditions will you become an author?]

Inventor-ship: [Is there any intellectual property that are likely to result from your summer work? If so, under what conditions will you become an inventor on a patent?]

Research Advisor's Signature_____Date_____

Student's Signature_____Date_____

Appendix C

Pre- and Post- Assessment Tool for Undergraduate Research Mentors

To what extent do you feel that your protégé can…

1. conduct a literature search and identify the relevant literature in your field?

Not at all Novice Intermediate Advanced (as well as I can) Unknown

What evidence can you point to in order to support your answer?

_____

2. read and understand a technical article in your field?

Not at all Novice Intermediate Advanced (as well as I can) Unknown

What evidence can you point to in order to support your answer?

_____

3. carry out an experiment to test a hypothesis?

Not at all Novice Intermediate Advanced (as well as I can) Unknown

What evidence can you point to in order to support your answer?

_____

4. analyze and interpret experimental data?

Not at all Novice Intermediate Advanced (as well as I can) Unknown

What evidence can you point to in order to support your answer?

_____

5. orally communicate the results of their work to others [choose audience]?

Not at all Novice Intermediate Advanced (as well as I can) Unknown

What evidence can you point to in order to support your answer?

_____

6. communicate the results of their work in writing to others [choose audience]?

Not at all Novice Intermediate Advanced (as well as I can) Unknown

What evidence can you point to in order to support your answer?

_____

Appendix D

Mentoring Survey – Protégé's Survey Instrument

Please answer the following questions thinking about the person who was assigned to serve as your student research mentor.

My mentor is a(n):

____ undergraduate student

____ graduate student

____ postdoctoral student

____ faculty member

Over the course of the summer, how many hours did you and your mentor spend in face-to-face contact?

____ 0-5 hours

____ 5-10 hours

____ 10-15 hours

____ > 15 hours

The amount of time my mentor spent with me was:

____ too little

____ just right

____ too much

4-16. Please use the following scale to respond to the statements below:

1 my mentor did not do this
2 my mentor tried to do this but was ineffective
3 my mentor did this sometimes and was effective
4 my mentor did this frequently and was effective

1. ____ My mentor helped me gain a perspective on how my research project fits within my faculty member's research program
2. ____ My mentor helped me gain a perspective on how my research project contributes to ongoing research in my discipline
3. ____ My mentor showed interest in my development as a scientist
4. ____ My mentor showed interest in my success with my research project
5. ____ My mentor and I developed a relationship based on trust
6. ____ My mentor was available to answer my questions about my research project
7. ____ My mentor offered me constructive feedback when necessary.
8. ____ My mentor invited my feedback on his/her mentoring style and effectiveness.
9. ____ My mentor seemed so busy at times that I felt uncomfortable asking for help.
10. ____ My mentor treated me like a colleague.
11. ____ My mentor has influenced my career plans.
12. ____ My mentor did not allow me to take ownership of my research project.
13. ____ My mentor provided me with timely feedback on my skills and knowledge as a researcher.

Would you recommend your mentor to another student researcher?

____ yes

____ no

____ uncertain

Please explain your answer:

Have you had a “mentored” research experience prior to this one?

____ yes

____ no

If you answered yes, how did your experience this summer compare to you prior experience?

What characteristics made your mentor effective?

What characteristics could your mentor work on to become a more effective mentor?

Please feel free to share here any other comments you would like to regarding your mentoring experience this summer.

Appendix E

Mentoring Survey – Mentor’s Survey Instrument

Please answer the following questions thinking about your experiences with your protégé.

Over the course of the summer, how many hours did you and your protégé spend in face-to-face contact?

____ 0-5 hours

____ 5-10 hours

____ 10-15 hours

____ > 15 hours

The amount of time I spent with my protégé was:

____ too little

____ just right

____ too much

Please explain:

3-15. Please use the following scale to respond to the statements below:

1 I did not do this
2 I tried to do this but was ineffective
3 I did this sometimes and was effective
4 I did this frequently and was effective

1. ____ I helped my protégé gain a perspective on how his/her research project fits within my faculty member’s research program
2. ____ I helped my protégé gain a perspective on how his/her research project contributes to ongoing research in the discipline
3. ____ I showed interest in my protégé’s development as a scientist
4. ____ I showed interest in my protégé’s success with his/her research project
5. ____ My protégé and I developed a relationship based on trust

6. _____ I was available to answer my protégé's questions about his/her research project
7. _____ I offered my protégé constructive feedback when necessary.
8. _____ I solicited feedback from my protégé on my mentoring style and effectiveness.
9. _____ My protégé seemed uninterested so I struggled to be able to reach out to him/her.
10. _____ I treated my protégé like a colleague.
11. _____ I influenced my protégé's career plans.
12. _____ I helped my protégé to take ownership of his/her research project.
13. _____ I provided my protégé with timely feedback on his/her skills and knowledge as a researcher.

Do you think your protégé would you recommend you as a mentor to another student researcher?

_____ yes

_____ no

_____ uncertain

Please explain your answer:

Have you ever "mentored" a student in a research experience prior to this one?

_____ yes

_____ no

If you answered yes, how did your experience this summer compare to you prior experience?

Would you mentor an undergraduate again in the future?

_____ yes

_____ no

What would you do differently if you were to mentor again?

Do you think that the mentoring training program provided you with adequate support and training?

_____ yes

_____ no

Are there changes you would recommend in the mentoring training program for the future?

Do you have any other comments you wish to share?