Research Internships in Science and Engineering (RISE): Summer Research Teams—Faculty and Students Benefiting from Role Model Hierarchies

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Abstract

Research Internships in Science and Engineering (RISE): Summer Research Teams (SRT) is designed to use the research environment as a means of attracting and maintaining student interest in Science, Technology, Engineering, and Mathematics (STEM) fields. Aimed primarily at women, the program targets incoming first year students, undergraduates, graduate students, and faculty. RISE SRT is a ten-week team-based research experience. The team structure includes a Faculty Mentor, a Graduate RISE Fellow (a graduate student currently working with the faculty member on the identified research project), an Undergraduate RISE Fellow (an undergraduate student familiar with the faculty member's research), and up to four RISE Scholars (undergraduates new to the project recruited nationally). Since the program began in summer 2002, ten research projects have been completed.

Over the past two years the research experience has been assessed from a variety of perspectives, including a series of focus groups (e.g., RISE Scholars, Undergraduate RISE Fellows, Graduate RISE Fellows) and individual interviews with each faculty mentor. The Scholars from the first year of the program also completed a follow up survey one year after the completion of their summer experience. The RISE program staff conducted a post program assessment (PPA) for all aspects of the program, ranging from soliciting the faculty research proposals to the concluding research symposium. The results of the assessments will be discussed in terms of the following: 1. time commitment of mentoring undergraduates, 2. importance of setting expectations (for example, helping the faculty to think through their goals for the project), 3. issues related to participant selection (for example, the trade off between accepting participants who have completed one or two years of higher education versus those closer to graduation), 4. factors contributing to a successful and meaningful research experience, and 5. importance of a predominantly female research team.

Introduction

The RISE program was intended to address several commonly identified barriers to success for women in science, technology, engineering, and mathematics (STEM) fields[1,2,3]. While beyond the scope of the present paper to describe the RISE program in detail, RISE was designed to use psychological theory to create a maximally influential team environment[4]. Specifically, "role model hierarchies," led by a Faculty Mentor, were formed. RISE Mentors selected a graduate student (RISE Graduate Fellow) and one undergraduate student (Undergraduate Fellow) who were familiar with her research program as additional role models. Four undergraduates (RISE Scholars) were recruited nationally to participate in this team to complete a summer research project. The role model hierarchy concept relies on the levels of experience built into the team structure: new undergraduates can look to their advanced peer, the Undergraduate Fellow, for motivation and encouragement; the Undergraduate Fellow, already more committed to STEM by virtue of her interest in the research project sees the graduate student (Graduate Fellow) as a possible "next step" in her progression in the field. The last member of the hierarchy is the female Faculty Mentor herself: a STEM Ph.D holder--the epitome of achievement in the higher educational context. Together, the RISE team is a rich environment of potential influence for reinforcing undergraduate females' interest and ultimate retention in STEM fields.

RISE is now in the third year of implementation and ten research teams have participated in the program. Assessment of the program conducted over the past two years has included both quantitative and qualitative data (e.g., focus groups, one-on-one interviews, and questionnaires). The investigators have compiled the data with the goal of better understanding the impact of role model hierarchies on the undergraduate research experience and how to maximize the success of the experience for future RISE teams. In this light, five key observations emerged and will be discussed in the sections that follow:

- Recognizing the time necessary to mentor and lead undergraduate research teams
- Recognizing the importance of expectation setting for all participants (e.g., helping the faculty to think through their goals for the project)
- Recognizing issues related to participant selection (e.g., the trade off between accepting participants who have completed one or two years of higher education versus those closer to graduation)
- Understanding factors that contribute to a successful and meaningful research experience
- Appreciating the importance of a predominantly female research team

Time Commitment of Mentoring Undergraduates

All faculty (N=11), regardless of seniority, indicated they valued the experience of mentoring a RISE team. However, many reported feeling stress due to the short time period (ten weeks) in which to conduct the research and meet RISE program expectations. The time issue was exacerbated by the nature of the research process itself, with periods of time when the workload was intense contrasted with periods where scholars felt "there was nothing to do."

Tenured faculty participants expressed concern for untenured faculty involvement in the program. Tenured faculty mentioned the lack of value given by departmental chairs for

involvement in so called "women's or girl's" programs. RISE is a high quality program well supported by upper level campus management. Some faculty expressed hope that RISE would change chairs' perceptions about faculty's involvement in programs related to supporting women and thus recognize this type of mentoring as contributing to a new professor's tenure package.

Indeed, the fears of the tenured faculty RISE Mentors were justified: untenured faculty reported they underestimated the amount of time their RISE team required. The time issue was compounded by the Scholar's age, academic level, and experience. Projects that included mainly sophomores required more time and effort from the Faculty Mentor and Graduate Fellow than projects that included more experienced junior and senior level students. In addition, some of the requirements of the RISE program itself were viewed as demanding by new faculty. For example in the first year of the project, faculty participated in weekly training activities with their students. Based on their feedback, the requirement of faculty participation was dropped in subsequent programs. In addition, the administrative staff of RISE will work with future faculty mentors to help them appreciate the requirements of the program and attempt to avoid over commitment.

Despite the time commitment, there was a payoff in terms of the faculty member's own research program. Several faculty have published (or are in the process of publishing) their summer work with the Scholars as co-authors. Two Mentors collaborated on a new interdisciplinary project, which was later funded through NASA.

Importance of Setting Expectations

Setting clear expectations for all participants is important to a successful and satisfying research experience. For the faculty, a mentor training program was a particularly effective vehicle for helping them (and the Fellows) understand the RISE staff's goals for the program. In that session, faculty heard from Mentors from the previous year about "what worked" and how to handle typical issues that occur in the course of conducting research with undergraduates. Issues such as workload, vacation time away from the project, as well as the role of the graduate student were clarified during this training.

Faculty were encouraged to set reasonable expectations for the research project and for the level of expertise brought to the research team by undergraduate students. Faculty with more open ended, exploratory research found they had more difficulty managing and motivating the students compared to faculty with more specific projects. The most successful projects were those that required a large number of "hands" and less experience, compared to those that required a steep learning curve before students could be useful or productive in the lab. Mentors observed that the students often blamed themselves when things went wrong as opposed to understanding that setbacks are a natural part of the research process. For most of the participants this was their first experience with conducting actual research versus "canned" laboratory experiments.

During the assessment interview, one younger faculty reported the qualities she looked for in the Scholars did not align well with the goals of the research project. She also recognized that her project was not adequately defined for students who lacked intrinsic motivation. In looking

across the faculty interviews, we noted that when older, more mature undergraduates were selected, the summer experience was more valued by the Faculty Mentor.

From the point of view of the Scholars as well, clear expectations regarding the process of conducting "real research" and their role in the project was critical. This issue was raised in both years of the program. In an attempt to address this concern, a guide was provided to all RISE participants that described the research process itself to give team members a point of reference. However, in the second year, all teams again indicated a frustration with the research process suggesting the handbook was not used or was not sufficient. With a lack of understanding of the research process, Scholars reported feeling like they were doing something wrong if they did not have work to do "all the time." They felt other people thought they were wasting time, even though in many cases they were waiting for parts to arrive or experiments and computer programs to run. On the other hand, many Scholars reported they valued figuring things out on their own and recognized that ambiguity and uneven work pacing were both the challenge and opportunity of conducting research.

Teams with more experienced undergraduates realized that they could only expect to accomplish so much in ten weeks and that uneven progress was "the nature of the beast." In contrast, one of the teams composed of younger undergraduates was not successful in managing the team project as a group. Their Mentor converted the team project into a series of four independent projects half way into the summer. She felt the team was unable to handle a collaborative research effort due to a lack of focus, motivation, and experience. This particular team expected research to be thrilling. One participant even when as far to say "there was no drama…[it was] not exciting." While the Mentor herself indicated she would change the research project in retrospect, the importance of setting expectations about the nature of the work and what is "good performance" on the part of undergraduates is clear.

Expectation setting for the faculty extended to more than just dealing with the Scholars. Graduate Fellows also needed help understanding what to expect from undergraduates. One team noted that their Fellow "was helpful but you had to ask her. She didn't initiate anything." Some of the undergraduates observed that the Graduate Fellows were very reserved; however, as they became more comfortable with each other, the Graduate Fellow began to trust the Scholars with more responsibilities. In the future, the Faculty Mentors may need to prompt their Fellows to be more proactive in the laboratory asking the undergraduates if they had any problems and to talk about what they were working on.

Issues Related to Participant Selection

Each year, five faculty members are selected to mentor a research team. In addition to the Faculty Mentor, each team consists of two to four Scholars (undergraduates recruited nationally), and an Undergraduate and a Graduate Fellow already familiar with the faculty's research. For most Faculty Mentors, RISE was their first research experience working with a team of undergraduates over an extended period of time. All scholars in the first year of RISE were female; in the second year all but one Scholar were female. In the first year of the program, three of eighteen participants were rising sophomores compared to six of sixteen in the second year. The faculty indicated that involving the younger participants required more training and

supervision than the older students. They suggested the need for more competitive compensation to attract older students who had a wider variety of opportunities to choose among. Ironically, the younger students all indicated strong, positive feelings about their involvement in RISE. Perhaps because they had less academic background and therefore, fewer opportunities to conduct funded summer research, these students highly valued their experience. The disconnect between the younger students' satisfaction and the dissatisfaction of the Faculty Mentors is something the RISE staff will have to address in future years of the program.

Factors Contributing to a Successful and Meaningful Research Experience

The two previous topics on expectation setting and participant selection are obvious keys to a successful experience. Clearly established research and program goals help the participants evaluate their experience realistically. In addition, identifying the method and frequency of contact between the Mentors, Fellows and Scholars helped the Scholars match their expectations to those of other members of their team. Mentors and Fellows who had regular contact, whether through meetings or email, made for happier participants. Scholars that did not know when they could or would be able to work with their Mentors or Fellows expressed less satisfaction with their summer research experience.

As noted above, participant selection has been challenging: what appears to be good for the undergraduate student is not necessarily good for the Faculty Mentor's research program. The mentors preferred working with more mature students: those who were motivated and took initiative. However younger Scholars highly valued their experience, were enthusiastic learners and indicated a strong desire to seek out future research experiences. Thus in terms of filling the STEM pathway, it can be argued that involving younger students, despite their steeper learning curve is in the best interests of the field as a whole. In any case, clearly defining the roles and responsibilities of the participants and discussing how each Scholar is expected to contribute to the team (and why she was selected) will enhance Scholar's experience. Other factors contributing to a successful team experience based on our assessments are described below.

RISE Infrastructure: Mentors, Fellows, and Scholars alike indicated that the infrastructure provided by the RISE staff was a key to their project's success. The non-research aspects of managing an undergraduate team for the summer, (e.g., securing student housing, orientation, training sessions on research and teamwork, and payroll logistics) were well planned and handled by the RISE staff thus, enabling the faculty to focus on the research project itself.

Role Model Hierarchy: Having multiple levels of contact within the research team also contributed to overall success. Scholars liked working with colleagues (other Scholars) because "it was not as intimidating" as working alone. They also reported using their Fellows as first level problem solvers so they did not have to "bother" the Mentors constantly with questions. In all but two teams, the Scholars thought the Graduate Fellow was a vital component of the team. In the two cases where the Graduate Fellow was seen as unhelpful, the Undergraduate Fellow was able to compensate. The Scholars appreciated the Fellows because of their "availab[ility] to help," they "didn't treat them like they were stupid" and they "could REALLY ask the questions they wanted…[they] didn't talk down to them." The Fellows were an important source of positive feedback and support for the Scholars.

Positive Relationship with Faculty Mentors: Almost all Scholars and Undergraduate Fellows said that one of the highlights of their experience was being able to work directly with a female professor. The Scholars generally found the Mentors were very understanding and helpful. Many Scholars got to know their Mentor on a personal level. Several Mentors invited the Scholars into their homes or took them on field trips. The Scholars found they could talk to their Mentors about virtually anything including career goals, graduate plans, and how to balance home life and work. One Scholar pointed out that she never saw faculty at her school and the contact was exciting. A highly regarded quality of the Mentor was that she was "*challenging but supportive when things went wrong.*" The Scholars understood their Mentor "had confidence in their abilities to learn." In all cases, the participants appreciated the Mentors' availability (and complained about Mentors who were rarely seen).

As can be expected, not all individual Scholars and Mentors had good working relationships. One team felt that their Mentor was disappointed with them and in their quality of work. This team had to learn professional behaviors appropriate to a laboratory environment. Because the Mentor had to address basic issues (e.g., coming to work on time, calling in when sick, and appropriate dress and language), the team may have felt diminished respect from the Mentor. In addition, this team reported a lack of interest in the research project as well as a range of majors, some of which seemed out of sync with the research project.

Project Preparation: One of the findings from the student focus groups was the importance of having the research projects and laboratories fully prepared prior to the Scholars' arrival. This preparation included securing supplies and equipment and preparing the other people who work in the research laboratory for the arrival of the RISE team. Issues related to broken/faulty equipment or supplies that had been ordered but had not arrived prior to the start of the project were noted. In addition, the lab environment itself was intimidating to some groups, to the point where they were not comfortable asking questions. Scholars who reported participating in on-going, regularly scheduled lab meetings had more positive research experiences. During these meetings, the Scholars realized they could ask questions, and in fact, some were forced to interact. Through this means, Scholars learned more about lab operation, gained confidence in themselves and their ability to think critically, as well as improving their understanding of the overall research topic.

Two of the teams from 2003 gave specific recommendations to improve project preparation. These included a required reading list related to the research topic sent out prior to the start of the summer, an orientation to the project during the first week including an introduction to the lab (equipment and personnel), a tour of the machine shop, an overview of the research process, a research plan or summer timeline, and a set time each week for team question and answer sessions.

Midway into the summer the Scholars participated in a program review and analysis. This activity was the most valued outside of the research experience itself (the average was 4.80 on a scale of 1 "strongly disagree" to 5 "strongly agree"). This rating was reinforced by the positive comments made in the focus groups. This midpoint "check in" session was appreciated because it offered the opportunity to discuss and compare progress with other teams. Many were

frustrated and unhappy they were not further along in their research. After listening to all RISE teams voice concerns, the participants realized that their situation was not unique. For many teams, this meeting was a turning point. The teams were encouraged to discuss their concerns with their Mentor and Fellows to resolve the problems. They also enjoyed learning about the research others were conducting.

A Room of Their Own: In the second year of RISE, a centrally located space was secured for the RISE participants. The Scholars appreciated this space as a place to relax and mingle. It provided a break from the laboratory which could be overwhelming at times. The space also facilitated cross team friendships and interactions. Because only RISE participants had access to the space, it also functioned as a "home away from home" where personal materials could be stored and free time enjoyed with others.

Public Support and Acknowledgement: The RISE Summer Research Team program concluded with a Research Symposium. Members of the National Science Foundation, Deans of the Colleges of Engineering and Computer, Mathematical and Physical Sciences were invited; in addition to the Scholars own families. The Symposium thus provided a public forum for the review and celebration of the accomplishments made by Scholars over the course of the summer. In this context, the teams gave presentations of their work which required a synthesis of the various aspects of the research and a method of delivery that was appropriate to a diverse audience.

Importance of a Predominantly Female Research Team

Because the RISE program specifically targets and encourages women to become involved in research, the significance of predominantly female research team experience to the participants was not a surprise. As noted previously, in the first year of the program, all Scholars were female. While the research team was entirely female (Scholars, Fellows, and Faculty Mentors), the Scholars did interact with male graduate students and post docs in the Mentors' research labs. In the second year of the program, one male Scholar and one male graduate student formally participated in the RISE program.

Many of the students indicated wanting to participate in RISE specifically because of the focus on women and the availability of a female Mentor. As a result of being involved in RISE, Scholars reported relating to their Mentors as "real people," and perhaps most importantly, seeing themselves as women scientists in the future. The Mentors and Fellows felt that the discussions were more open than in the typical co-ed environments. Scholars could focus on learning rather than worrying about "behaving like a woman is expected to [behave]." Several pointed out "you never see three or more women sitting around discussing science…except during RISE."

Another positive outcome reported by the Graduate Fellows was a new appreciation of the team's Faculty Mentor (who was also their research advisor). Through the shared experience of advising and mentoring undergraduates, the Fellows strengthened their relationship with their advisor. RISE also opened a dialogue about women's issues in STEM between the Fellows and

Mentors. The Fellows reported a renewed commitment to their degree program and future in STEM.

A key goal of the RISE program relates to removing or minimizing the barriers women face in STEM fields and majors. In the first year of the program, discussions related to women's issues in STEM were incorporated into the weekly training sessions. The Scholars complained about the need for these because being a woman in STEM was "not a problem;" and that being female was something that only impacted the earlier generation. In contrast, Graduate Fellows were a more rapt audience for this material. In order to frame the discussions of "chilly climate," "critical mass," and the history of women's progress in STEM, a "book club" exercise was introduced in the second year of the program.

The goal of the book club was to generate a discussion of the barriers women face in STEM and coping mechanisms used through the means of biography. Reading the stories and struggles of women in STEM provided another context for discussion beyond their own personal experience. Participants selected one of two books to read: *Hornet's Nest* by Missy Cummings[5] or *Rosalind Franklin and DNA* by Anne Sayre[6]. These books were chosen because they offer either a historic (Sayre) or contemporary (Cummings) look into the world of a woman in science (chemistry and engineering aviation, respectively). The book club experience was highly rated by the Scholars (4.27 average on a scale of 1 "strongly disagree" to 5 "strongly agree"). One of the Scholars who read Cummings' book emailed the author directly to tell her the RISE program was reading *Hornet's Nest*. Cummings responded by coming to campus to meet the scholars and discuss her experiences as one of the first women fighter pilots in the US Navy (who ultimately left the Navy due to unrelenting sexism). Her participation and the resulting discussion on women in science was a highlight of the program for many Scholars.

Thus, discussing issues related to discrimination and sexism using the book club format enabled the Scholars to come to new understandings and awareness. The Scholars appreciated "pool[ing] our resources to solve problems we all have had." The discussions caused many to reflect upon their own opinions about the role of women in STEM. Some Scholars identified with the books and received encouragement by understanding that they were not the only ones facing some of the struggles that were discussed. Finally, having Missy Cummings come to campus and tell "her story" in person brought the messages home in a way that not even a vividly written book could do.

Recommendations and Conclusion

Evaluating the experience of all RISE participants has been critical to the program's success. Using both quantitative and qualitative methodologies, the project has been evaluated and improved each year. Based on our experience and assessment, the following recommendations can be made.

1) Scholars should be prepared for the reality that research can be frustrating. Past participants did eventually learn to have patience with the process, but setting this expectation from the outset may prepare students for an uneven course in the laboratory. Because the Scholars are transitioning from the structured world of the classroom to a

more nebulous environment of the lab, establishing interim deadlines throughout the summer would help them have more reasonable expectations and less anxiety.

2) The Faculty Mentors should be encouraged to comprehensively organize their research projects prior to the Scholars arrival. Materials should to be ordered well in advance so the teams do not waste time waiting for supplies to arrive. Minimal expectations for contact with RISE students should be explicated with a strong recommendation for regular lab meetings with all involved in the research project.

3) Graduate Fellows should be specifically prepared by their Mentor's regarding their responsibilities in working with the team. To help the Graduate Fellows feel more comfortable with their role in the program, Mentors may want to involve them in the participant selection process. Because Fellows are one of the main supervisors of the Scholars, this may help them become more proactive in helping young Scholars with their first research experience.

4) Faculty need to understand the tradeoff between selecting younger versus older Scholars to participate on their team. While there are pluses and minuses for both choices, the nature of the Mentor's work with students is different depending on the degree of course work the student has completed, their commitment to the field, and over all maturity.

In sum, the evidence from our various assessments provides support that RISE meets its goals to assist in minimizing common barriers to success in STEM fields (among these: lack of female role models and a "critical mass" of women, the "shadow job" expectation for female faculty of mentoring students even though they receive little formal recognition or reward, the chilly climate of STEM, and students' low self-perception of ability and confidence). Specifically as a result of participation, RISE Scholars are more firmly committed to STEM; seven Scholars and Undergraduate Fellows are pursuing advanced degrees. Faculty Mentors have received formal recognition for their participation, and more importantly, many have developed new research initiatives, published papers, and secured additional funding from funding agencies. Graduate Fellows have felt understood and have developed closer, more personal relationships with their advisors. Both Mentors and Fellows have reported a renewed enthusiasm for working with undergraduates in the context of research. Finally, given the considerable time commitment of RISE and other research, teaching and service demands on STEM faculty, the result that three out of eleven Faculty Mentors have returned to participate in the 2004 program is one more indicator of success.

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