Research Internships in Science and Engineering (RISE)

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Abstract

In science, technology, engineering and mathematics (STEM) fields, the low presence of women has been well documented. Barriers contributing to the problems have been identified as external or contextually based, and internal or individually based.[5, 10] These barriers include the lack of female role models, the shadow job expectation for female faculty and low self-perceptions of ability by undergraduate women.[8, 20, 21]

At the University of Maryland (UM), an innovative educational intervention is being introduced in summer 2002 to help overcome some of these barriers. Research Internships in Science and Engineering (RISE) serves women in the higher-educational pipeline: incoming first year students, undergraduates and graduate students. This program has two tracks. For incoming first year students, there is a ten-day orientation to engineering, the sciences and the UM community. The goal is to jump-start the careers of female students by providing them with teamwork and technical skills training and networking opportunities with both female faculty and each other, as well as exposure to research in STEM fields. For upper-level undergraduates, the second component of RISE consists of an eight-week team-based summer research experience.

The purpose of this paper is to describe RISE and identify how this program uniquely addresses some of the issues that women face in STEM fields via the two program tracks. The implementation of this program will begin in summer 2002. This program is funded by a grant from the National Science Foundation, the Clark School of Engineering and the Office of the Provost at the University of Maryland.

Motivation

The low representation of women in science, technology, engineering and mathematics (STEM) fields is well documented. This trend continues due to the low numbers of women enrolling in undergraduate STEM programs, the subset that persists to graduate, the fewer numbers that enter graduate programs and the exceedingly small number of women who become faculty members.[8] Over the past fifteen years, the percentage of women earning bachelor's degrees in engineering remained relatively unchanged.[17] This is in strong contrast with the number of women entering business, medicine and law, which are previously "female scarce" fields.[10]

From a recent literature review on women in STEM fields, many factors inhibit women from entering, persisting or advancing in STEM.[8, 9, 10] These barriers have been classified as "external" and "internal."[10] External or contextual barriers refer to structural factors that are characteristics of the environment impeding access to opportunities within that environment.

Examples can be found in norms, policies and practices within an organizational system. Occupational stereotyping, occupational discrimination and a paucity of role models, mentors and collegial support (in other words, lack of a critical mass) are other examples of external barriers. A common issue for female faculty members is involvement in activities that women tend to be motivated to undertake due to personal values, for example mentoring. These types of activities, referred to as "shadow jobs", can be time consuming and without reward in the promotion and tenure process[10].

Internal or individual barriers arise from societal beliefs and attitudes that restrain vocational development.[10] These factors are detrimental when individuals internalize the set of beliefs that perpetuate the misconceptions about their capabilities. Included as internal barriers are underestimation of one's capabilities and gender role socialization attributes, for example, inappropriate self-blame.

Research Internships in Science and Engineering (RISE) Program Description

The purpose of Research Internships in Science and Engineering (RISE) is to create all-female research teams, facilitated by female faculty members (Faculty Mentors), graduate students (RISE Graduate Fellows) and advanced undergraduate students (RISE Undergraduate Fellows) who are paid and trained to perform significant mentoring and teaching of undergraduate and incoming first-year women. There are two key points in the career of undergraduate women where positive interventions can significantly impact success: 1) during the transition from high school to college (which tends to be the initial encounter with the male dominated environment) and 2) during the latter half of their undergraduate education, when career options, including whether or not to pursue graduate education, are being considered. Accordingly, two different tracks are provided: RISE – The First-Year Summer Experience (Track One) and RISE – Summer Research Teams (Track Two). Faculty Mentors and Graduate and Undergraduate Fellows participate in both tracks.

RISE – The First-Year Summer Experience (Track One) is designed to be a ten-day residential orientation program for first-year female students entering engineering, mathematics, computer science or physical science at the University of Maryland (UM). During this program, students interact with five Faculty Mentors, five RISE Graduate Fellows, five RISE Undergraduate Fellows, members of the Women in Engineering Program staff and BESTEAMS (a team training research center) faculty resulting in a successful introduction to engineering and the sciences. Students also network with participants in the RISE – Summer Research Teams program for additional exposure to women who are enthusiastic about pursing STEM degrees. The focus of the orientation is to address issues of self-confidence and self-efficacy with regard to the incoming students' ability to be successful during their initial year.

Previous research indicates that female students often enter STEM fields with fewer technical skills, computer expertise and/or confidence than males. The summer orientation will include a mini-course, *Technical Survival Skills for Freshmen*, taught by RISE Undergraduate Fellows.[14] In this course, incoming students will learn or review basic computer skills, have hands-on experience taking apart and rebuilding a computer and learn how to use the electronic

communication facilities at UM. Faculty Mentors will provide orientations to their laboratories and research projects. In this context, students complete structured experiments or laboratory exercises in small teams. Students will also participate in a series of "Lunch and Learn" sessions where Faculty Mentors and practicing engineers and scientists discuss their personal experiences in science and engineering.

Because the orientation program is developed around a team environment, participants will receive training in team and professional skills. The emphasis of the training focuses the incoming student on learning about her own personal strengths and weaknesses, basic interpersonal communication skills such as giving and receiving feedback and personal time management strategies.

Students conclude their experience by writing a team report on their roadmaps for success in STEM disciplines. Participants, Faculty Mentors, RISE Fellows and members of the RISE Advisory Board will be invited to a concluding reception where the students will receive RISE certificates of accomplishment from the Dean of the Clark School of Engineering and the Dean of the College of Computer, Mathematical and Physical Sciences (CMPS). Parents of the participants are encouraged to attend the reception based on the emerging evidence that parental support and encouragement are important to the success of young women in STEM fields.[14] Participants who successfully complete this program will receive $500 at the beginning of the fall semester.

RISE – Summer Research Teams (Track Two) involves a guided research team experience for rising junior and senior females majoring in engineering or the sciences. This program is designed as an eight-week experience in a female faculty's research group. The participants will receive $3,000 stipends.

The goal of the Track Two program is to encourage young female students to remain committed to their STEM major, become excited about research and increase their network of female contacts in engineering and the sciences. The *means* by which the Faculty Mentors achieve these goals may differ by academic discipline. The ideal team consists of a Faculty Mentor, a RISE Graduate and Undergraduate Fellow and four undergraduates all working together on a common research project. However, in some science fields such as physics, smaller teams may be formed due to the scarcity of female students interested in the same research area. These "mini-teams" are brought together on a regular basis with their faculty mentors to discuss tips on how to succeed in their particular academic discipline, graduate education and team training.

Depending on their mentors' preferences, teams will work on a variety research outputs, for example: 1) a research poster to be presented at the Research Symposium on the last day of the program; 2) written results in the form of a classroom learning exercise, short paper or extended abstract; or 3) a "research portfolio" which documents the impact of their team training experiences. The purpose of the portfolio is to provide material for eventual graduate school application or future employment. While the core experience for Track Two participants is involvement in the research experience itself with the benefit of several role models and mentors, students will also attend three half-day workshops on effective mentoring and advanced team

skills training, for example knowledge of identity development, group dynamics, project organization and decision management.

The concluding event of the Track Two program will be the *RISE Research Symposium*. The symposium is a daylong event during which participants receive feedback on the posters and research reports from mentors and advanced students. As part of the symposium, there will be seminars on preparing for graduate school and characteristics of a career in academe. This component is designed to encourage women to enter higher education to increase the number of women needed to reach "critical mass" in STEM fields. The Deans of the College of Engineering and CMPS, members of the RISE Advisory Board and the parents of participants will be invited to attend.

Recruitment and Selection of Participants

The Track One participants will be recruited to the RISE Program through the following means:

- Three college open houses conducted for potential incoming freshman students,
- Information on the Women in Engineering Program's website and
- Direct mailings to students who have been accepted into the Clark School and CMPS.

The target audience for the orientation includes those students who fall between the 25^{th} and 75^{th} percentiles in terms of the entry characteristics (grade point average, math SAT and overall SAT). This student population was determined based on the recommendation from the RISE Advisory board members who have extensive experience with recruitment and retention programs for underrepresented students. Participants in the Track One program will be selected based on their high school transcript and a statement of interest that describes why the student would like to participate in the RISE First-Year Experience.

The Track Two participants will be recruited using a variety of listserv notifications, information provided on the Women in Engineering Program's website and direct mailings to a variety of colleges and universities. In addition, the Faculty Mentors are encouraged to identify potential recruiting sites specific to their academic discipline. In future years, the Track One participants will be recruited for the Track Two program.

The selection process for Track Two participants is similar to that of the Track One participants. Each student will submit a current transcript, a statement of interest in a specific research project and a description of her career goals. The descriptions of the projects that the students can choose from will be available prior to the application process. The Faculty Mentors and RISE Co-directors will evaluate the applications.

The RISE Graduate and Undergraduate Fellows will be selected at the discretion of the Faculty Mentor. Because each Faculty Mentor has flexibility in designing the research experience for her RISE participants, each mentor must also have the authority to choose the most appropriate peer role models.

Faculty Mentors will be selected through a proposal process. The proposals will include an overview of the project, the role of the faculty mentor, the graduate and undergraduate fellow and the four undergraduates and a budget. RISE advisory board members, who are a diverse group of individuals with high-level institutional and national perspectives on technical education, will review the proposals. Considerations for proposal selection include:

- Potential interest of the research topic to undergraduates
- Potential for significant learning experiences for undergraduates
- Feasibility of the research to be conducted as a team-based experience
- Willingness of faculty member to provide sufficient supervision to the undergraduates and to participate in Track One activities.

How RISE Addresses the Barriers in STEM

At UM, several key barriers were identified as blocking the access of STEM fields to women. The external barriers include lack of a critical mass of women, lack of female role models for students, the chilly climate of science and engineering and the shadow job expectation of female faculty. The internal barriers include students' lack of self-confidence, underestimation of ability (referred to as self-efficacy) and stereotypical attitudes.

The RISE program principles include:

1) using all-female teams to conduct research,
2) using the faculty members' own research agenda as the context for learning and
3) paying and training participants (faculty and students).

The research team setting was selected to directly address industry's demands and accreditation standards.[1] Student project teams are becoming commonplace in engineering and science education. Positive team experiences have been shown to motivate students and encourage higher levels of academic achievement leading to increased retention and graduation.[3, 4, 11, 22] However, a common experience for women on undergraduate engineering and science teams involves being in the minority. The team environment may then present yet another challenge for the female student in dealing with isolation, rather than being a potential source of peer support as intended.

Through the use of all female teams, we can create a positive "micro-environment" for students. In STEM fields, female students often view female faculty members as role models and potential mentors. A role model is an example of the student's aspirations. She demonstrates how to succeed in a context or environment in which the student envisions herself in the future. Research on role modeling suggests that the greater the perceived similarity, the greater the impact of the role model.[2, 7]

In the design of RISE, we take advantage of social psychological influence by providing a hierarchy of role models for participants, thus creating an enhanced team experience. The enhanced team consists of: the RISE Undergraduate Fellow who is a peer, the RISE Graduate

Fellow who is a more advanced role model committed to science and engineering by virtue of seeking an advanced degree and the Faculty Mentor who goes beyond role modeling to mentorship. Furthermore the RISE undergraduate participants also serve as role models to the incoming first year students in the Track One program.

While male faculty members serve effectively as mentors, the literature suggests that women serve as particularly effective role models.[23, 25] Furthermore, the literature on social learning suggests that individual learning is strengthened when role models are perceived as similar along salient dimensions such as gender, age and ethnicity.[2, 19]

Different than role models, mentors actively engage in their protégés' lives, encourage their occupational success and advise them on various areas of personal and professional concern.[12] Whitlock[24] noted that faculty mentors play various roles at different points in a female student's educational experience. During the early years of college, mentors help students' identify and affirm interests and explore possible career fields. In later years, mentors serve a sponsorship and networking role in connecting students with opportunities related to jobs and graduate school.

The most helpful aspects of mentoring include validation of the female students' academic abilities, empathy with their anxieties, contact with women scientists and engineers who can refute career stereotypes and provide career advice.[6] While theory and experience support the importance of female mentors and role models to young women in STEM, a major problem in establishing female faculty led teams is their sheer lack of numbers. Reasons for this absence of female faculty include a lack of a productive pipeline (for example, few female undergraduates majoring in these field and fewer still interested in academic careers), the "chilly climate" in STEM that pushes women to leave and those remaining are often burden with shadow jobs, which impedes advancement.[10, 20] Now aware of the fact that shadow jobs do not contribute to job advancement, many junior faculty members elect not to participate in volunteer activities that involve undergraduate women students, thereby further reducing the potential mentor pool.

To enable faculty to participate in this program without their participation becoming yet another shadow job, they will be paid one month's salary (up to $8,000) and will have financial support for their research. In addition, to receive credit towards promotion and tenure, the award will be in the form of a grant. The additional funding associated with each grant includes support for personnel and equipment. RISE Graduate Fellows will be paid a $2,000 stipend supplement to augment their existing graduate assistantship funding. The Graduate Fellows assist the faculty member with the RISE program. In addition, faculty members can choose to fund an Undergraduate Fellow, an outstanding female undergraduate student already involved in her research. The Undergraduate Fellows receive $4,500 for their participation in RISE. $1,000 is available for supplies and equipment.

Due to a need to publish research results in academia, RISE uses the faculty member's own research program as the setting in which the student teamwork and mentoring will occur. Female faculty members are supported in their mentoring of young women and at the same time, make progress in their own research program.

Evaluating the Success and Impact

The RISE program evaluation will have multiple components. A formative plan has been designed where feedback from the first cohort of student research teams will influence the program in subsequent years. Because RISE is designed as an educational intervention, the evaluation of program content and participant success is critical.

RISE students' single gender team experiences will be evaluated for increased satisfaction with and sense of confidence in their major and career choice, outcome expectations and perceived barriers and supports using self-efficacy instruments. Track One and Two cohorts will be asked to complete the measures of these constructs on annual basis throughout the period of our NSF funding in order to begin assessing the long term impact of RISE participation.

Students will complete a satisfaction survey assessing the various program elements at the end of the experience (for example, training in teamwork). The students' accomplishments as a result of their program participation will be evaluated. In the case of Track One participants, the student summary team reports will be reviewed. For Track Two participants, members of the Advisory Board will evaluate the research posters and papers during the Symposium.

A member from each of the five student teams in Track Two will be randomly selected and interviewed in a focus group. The focus group will be a vehicle to better understand the all-female research team experience. This interview will concentrate on students' reactions to the specific training experiences working with their mentors and RISE Fellows, the research component of their experience, and finally, their perceptions of the strengths and weakness of participating on an all-female team.

We will investigate the impact of project teams in engineering on student learning, satisfaction and persistence using the psychological construct of self-efficacy.[5, 15, 16] We are interested in determining if the all-female team acts as a buffer, socializing agent, or source of support and learning, for female students in male dominated fields. Similar to the well-documented impact of attending an all women's college, we would like to determine if participation in an all-female research team serves as an inoculation to the climate of academic science.[18, 21] For example, Ginorio and Wiegand[13] studied participants in a woman-only science program compared to a similar coeducational group. Students in the woman-only group reported increased desire to pursue a scientific career, as well as increased confidence in their abilities in the physical sciences.

In addition to self-efficacy measures, we will evaluate outcomes such as the students' commitment to STEM fields (by tracking academic performance and persistence in STEM majors of Track One participants), graduation and increased confidence in an engineering career and/or desire to attend graduate school and perceptions about women in science and engineering fields (e.g., observations concerning chilly climate issues, critical mass, strategies for effective role modeling) via post program focus groups (Track Two participants). Differences by science or engineering major will be noted. For example, RISE participation may make a stronger

difference for persistence in the majors where women tend to be less represent like Electrical Engineering and Physics.

The Faculty Mentors' experience will be included in the evaluation. We would like to determine the 1) degree of impact of *training* in mentoring and teamwork on their work with the student research team, 2) changes in attitudes towards *working with undergraduates* in the research context, 3) whether the *all-female research team* experience has unique dynamics and impact and 4) whether the experience was positive in terms of their own *research productivity*. To assess these questions, the faculty members and their RISE Graduate Fellows will participate in a focus group evaluation as well as an anonymous survey at the completion of each summer program. The information gathered will be used both as outcome data and when appropriate, used formatively for subsequent program improvement in the future.

Conclusion

The notion of a two track program, beginning with a front end experience to excite and prepare entering first-year female students, followed by an extended research internship in the later years that involves close contact with successful woman scientists and engineers, is a programmatic approach that others may adapt to suit their own institutional contingencies and priorities. Through the use of all female research teams, the RISE program will help to overcome the barriers to STEM fields identified at UM. These teams will create a micro-environment for the women, which includes role models and mentors from a variety of levels within the higher-educational pipeline. This aspect directly addresses the issues of a lack of critical mass and paucity of role models. The concept of paying and training the participants and conducting research on the faculty members' own research agenda helps to remove the problem of a shadow job. Furthermore, training the students in the appropriate skill sets and providing them with the various role models helps the students gain confidence in their own science, engineering and mathematics abilities.

At UM, the combined impact of RISE Track One and Two programs is anticipated to include 165 women STEM majors (over the three year funding period) who will be involved in science and engineering mentoring relationships and introduced to discipline appropriate research techniques. We expect to support 15 female faculty members on their personal research programs. These faculty members will be formally recognized for their contribution to mentoring female students.

The purpose of this paper was to introduce the RISE program, which will begin in summer 2002 and discuss how this program addresses some of the barriers women face in STEM. In future papers, the progress of this program will be reported including program implementation, evaluation and impact.

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