

Graduate Students Mentors in REU Sites

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Abstract – The Research Experiences for Undergraduates (REU) program supported by the National Science Foundation is designed to provide summer academic experiences for undergraduate students through participation in research. Although students are paired with faculty mentors to work on a research project, many times graduate students are highly involved in the mentoring process. In this paper, we evaluate the role of graduate students as undergraduate mentors, and its impact on the students, faculty and the objectives of the REU program in Computer Science and Engineering at the University of South Florida. Moreover, we provide some guidelines and suggestions to make this role a powerful opportunity for each of the parties involved in the program. Our results indicate that graduate student mentors contribute to the achievement of the REU program's goals, and that the mentoring experience is beneficial to undergraduate and graduate students and faculty. Finally, we also present some disadvantages and improvements to this approach.

Keywords: Mentoring, Research Experiences for Undergraduates, Graduate Students.

INTRODUCTION

The National Science Foundation supports many Research Experiences for Undergraduates (REU) programs throughout the country. One such program at the Department of Computer Science and Engineering at the University of South Florida (USF) has, for the last two years, involved undergraduate students in research, academic and social activities under the supervision of faculty mentors for 10 weeks during the summers. Three factors play a key role in the success of the program: the research environment, the students selected to participate in the program, and the mentors who define and guide the research projects.

Summer REU Sites are very resource demanding, before, during and after the program for both organizers and faculty mentors. Organizers have to set up and update the program's website, recruit students, select the participants, organize academic and social activities, make travel arrangements and secure accommodations, evaluate the program, produce reports, disseminate the program's results, and often serve also as research mentors to the student participants. Faculty mentors need to define the research projects before the program is started so projects can be advertised for interested participants, participate in the selection of the students, prepare lab infrastructure and work space, and spend significant amounts of time mentoring the students during the entire program. As a result, both organizers and faculty mentors have frequently utilized graduate students to help them in several of these activities. In this paper, we focus our attention on the role of graduate students as undergraduate mentors, and its impact on the students, faculty and the objectives of our REU program. Moreover, we provide some guidelines and suggestions to make the role of these graduate students mentor a very effective one. Based on our experience, and on information collected from students and mentors through surveys and interviews, we show

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that graduate mentors contribute to achieving the REU program's goals, and that the mentoring experience is beneficial to faculty and student participants.

Many papers and reports have been published about REU Site experiences [1,3,4,6,7,9], undergraduate guidelines [2,10,11], and mentoring guidelines [2,8,10]. However the role of graduate students as mentors to undergraduates has been seldom addressed. In [4], Humphreys affirms that students develop a collegial relationship with graduate mentors who are more approachable than faculty, especially during the summer semester, as this is the time for faculty to travel and concentrate on their research. Thus, faculty availability for programs like SUPERB (Summer Undergraduate Program in Engineering Research at Berkeley) is defined by the authors as unpredictable. Although the paper briefly mentions the role of graduate students as part of the program, it neither describes it nor evaluates it. Similarly, Donnelly *et al.* [3], briefly mention that graduate mentors provide pre-arrival project information for the REU students to have a smooth transition upon arrival and play a role model for them. In [1], the author mentions that students positively evaluated the student-mentor interaction experience. Although the author points to the fact that graduate students are assigned to undergraduate projects, the paper does not distinguish between faculty and graduate mentors.

Karasz, *et al* [5], provide an in depth analysis about one approach of graduate students mentoring undergraduates. They present a new role for a Teaching Assistant (TA) – that of a “Research Mentor (RM)” to help students develop class research projects. The project objective was to “emphasize undergraduate research skills training while also giving graduate teaching assistants quality teaching experiences.” They analyzed different implementations of that role in 1996. One of them was basically to conduct weekly workshops about “how to use the Internet to conduct research, how to write a thesis statement, the basics of English grammar, and how to give a presentation”. This approach was problematic since students complained about the topics and the RM preparation. Another strategy was to assign the RM the task of assisting students in the completion of a research paper. Although this approach worked well, in many cases involving unmotivated students, the RM did most of the work. The authors concluded that the new TA role as a research mentor contributes to improving the critical thinking skills of the students by combining active learning and mentoring. This approach is the closest to our work but the project complexity is limited to class work, and the research mentor is not necessarily involved with the results of the project. In addition, the student being mentored was not dedicated to research on a full-time basis.

The objective of this paper is to evaluate the role of graduate students as undergraduate mentors in a 10-week REU summer program. Based on the experience gained during the last two years, we explore here the benefits and drawbacks for students, faculty and the objectives of the program. We also provide guidelines for those who may want to consider following this strategy at other REU sites. As a convention, we will refer to the graduate student mentoring undergraduates as the “Graduate Mentor” or “GM”, the faculty member in the role of main and official mentor as the “Faculty Mentor” or “FM”, and the undergraduate student participating in the REU program as the “student”.

The rest of the paper is organized as follows. In the next section we briefly describe our REU Site. Then, we present how to select and involve graduate students as mentors. Then we present the results of the surveys and interviews to provide insights into the experience of all those involved: the graduate mentors, the REU students, and the faculty. Finally, we include a section on improvements and conclusions.

REU SITE DESCRIPTION

The REU site in the Department of Computer Science and Engineering at the University of South Florida offers multi-departmental research opportunities to undergraduate students. As described in [6], the program seeks to achieve four objectives. The first objective is to increase student involvement from under-represented minority groups, with an emphasis on Hispanic students from Florida and Puerto Rico. The second objective of the program is to better prepare undergraduates for their professional careers. Toward achieving this objective, the activities implemented involve students in research projects where they learn investigative methods and cutting-edge tools in their fields as well as activities meant to improve their writing and oral skills. The third objective is to increase the enrollment in graduate programs by providing the participants with relevant and timely information about graduate

program application procedures, deadlines, requirements and funding opportunities. The fourth objective is to improve the students' ability to learn independently.

Table I. REU participants 2005-2006.

Country	2005	2006	Total	
Hispanics Puerto Rico	6	5	11	42 %
Hispanics Other	2	1	3	11 %
African American	2	1	3	11 %
Whites / others	0	4	4	16 %
International	2	3	5	20 %
Total students	12	14	26	100 %
Women	3	4	7	27%

Social and educational activities play an important role in this program. These activities promote social integration and academic discussion among participants as well as cultural exchange and friendship. Social activities include: pool parties, welcome and closing lunches, visits to recreational parks and shopping centers, and small trips to well known entertainment and cultural venues. Educational activities include: workshops on poster design and oral and written presentation skills, seminars in library research techniques, group discussions on professional ethics, advising sessions on graduate program application procedures, deadlines, requirements and funding opportunities. In addition, visits to the Museum of Science and Industry and the Nanotechnology Center at USF have been part of the program. Mid and end-of-program project presentations, a poster competition, and a written research paper, are the main program requirements.

A total of 26 students have participated in this program since its inception 2 years ago, and we feel that so far the program has been very successful in meeting its objectives. Table I shows that sixty-four percent of all participants have been members of underrepresented minority groups. One African American and two Hispanic participants, after graduating from their respective universities, have enrolled in our Ph.D. program. The rest of the participants have either graduated and are pursuing careers in industry or are still successfully attending their universities. We have disseminated our findings via several educational publications. Among these publications there are two technical conference papers with the REU students as first authors. More detailed information about the program can be found at <http://www.cse.usf.edu/REU>.

GRADUATE STUDENT MENTORS

In this section, we describe how to select and involve graduate students in the REU mentoring role. We started including a few graduate students as mentors in our REU program since its inception in the summer of 2005. Based on the very positive experience that first summer of the program, we increased the participation of graduate student mentors the following summer - in 2006. Table II shows the number of REU students, faculty, and graduate student mentors that have participated in the program in the last two years. The table shows that we increase from three GMs in 2005 to eight in 2006. Moreover, it can be observed that half the REU participants have been mentored by GMs.

Motivation

There are different issues and opportunities which motivate the participation of graduate students as mentors in REU programs. First, from the faculty members' point of view, it is shown in different papers [4,6,9] that some

faculty experience difficulties in committing enough time to program development. Summer is the time for faculty to travel and immerse themselves in research and publication work. In addition, there are time-consuming activities such as project definition, in-lab training, paper and presentations review, and participation in workshops and social events that the REU program requires even before the students arrive. Therefore, involving graduate students in these activities allows faculty members, supported by the GM, to be more effective in the program. Second, from the graduate students' point of view, mentoring REU students is an opportunity to enhance their research projects and to develop mentoring skills especially useful for Ph.D. students with academic goals.

Table II. REU students and mentors in 2005-2006.

Role	2005	2006	Total	
REU students	12	14	26	100 %
Faculty mentors	7	8	15	57 %
REU student mentored by a GM	3	10	13	50 %
Graduate Mentors	3	8	11	

Graduate mentor profile

It is important to select graduate students who possess the following desirable characteristics, which will enable them to successfully assume the role of mentors. The graduate student should have some research experience and have knowledge of and be committed to the research project that the undergraduate will be working on. The graduate student should be highly motivated and must understand the goals of the whole REU program. GMs should be capable of not only guiding but also following guidelines set by the REU program and by the faculty mentors, since ten weeks is a relatively short period of time to complete a research project. Finally, GMs should have good communication skills.

GM activities before the students arrive

Before the program begins, the selected GMs are given a presentation about the program including its goals, activities, schedule, project deliverables, and some recommendations for succeeding in their new role as mentors. Then, they need to be involved in the following activities. GMs must participate in the definition and planning of the research project. It is very important for the project to be directly related to the GM's area of research. In fact, the REU project could be defined as a sub-project of the GM's research resulting in a stronger commitment by the GM to the program. The GM must also establish communications with the REU student assigned to the project and send preliminary information such as papers, web links, book references, and other relevant information to the student so he/she will be better prepared. Finally, the GM has to make sure that all the resources needed for the student to perform his/her work – basically, for our program will be software, hardware and space – are available and functional.

GM activities during the program

Clearly, the main activity to be performed by any mentor during the 10-week REU program is to guide the student through the research plan previously defined. We do not pretend to present tips about how to mentor. Instead, we focus on those activities that are specifically performed by GMs to reach the REU program's goals. We want to emphasize the fact that the GM supports the mentoring process, but a successful student research experience is the responsibility of the faculty mentor. Accordingly, the main activities that a GM has to perform while the REU students are on site are the following:

- Project presentation. Students arrive with many questions, ideas, and in some cases misconceptions about the project. A kick-off research meeting helps the student understand the problem, the research plan, and

clarify any misconceptions. For the GM, this is the time to present the project and to ascertain the students' backgrounds and general weaknesses. This meeting is led by the FM who clarifies the role of the GM.

- Progress control. Formally twice a week, the GM meets with the student to check his/her progress according to the research plan. In general, the student's work place is in close proximity to the GM's. Therefore, the student has almost 100% access to the GM.
- Review of deliverables. The GM reviews and corrects all the project deliverables, such as the mid-term and end-of-the-program presentations, the conference paper – if one is planned, and the poster design for the end-of-the-program competition.
- Logistic support. The GM sometimes has to deal with project-related logistical problems, such as new software or hardware requirements, network issues, and other unexpected problems that may occur during the project execution.
- Social and academic interaction. GMs are encouraged to share their experience as graduate students. Out-of-the-lab activities such as workshops, seminars, and social events, give students a broader picture of what it is like being a graduate student. Students participate in workshops such as working in research teams and effectively using library resources. It is helpful if GMs participate in these workshops with the students.

Table III. 2006 survey to evaluate the GM experience.

	Yes	Not	Unsure
Did the student's work help you to make progress in your research work?	71 %	0 %	29 %
Did you develop new mentoring skills from this experience?	71 %	0 %	29 %
Did the student's work help you to publish your research work?	72 %	14 %	14 %
Did the student's work help you to make progress in your research work?	100 %	0 %	0 %
Would you like to continue to mentor students in the future?	100 %	0 %	0 %

GM activities after the students leave

For the GM, one of the expected results of the REU experience is a publication. Once the 10-week program is over and the student leaves, it is the GM's main responsibility to achieve that goal. That may require performing new experiments and/or analysis based on the results obtained by the REU student. In <http://www.cse.usf.edu/REU> there is a link to different publications related to our program, many of which have GMs as co-authors.

THE GRADUATE MENTOR EXPERIENCE

We administered a short survey and performed individual interviews with several GMs. Table III shows the main results. In general, GMs consider the REU program to be a learning experience they can use to obtain research benefits and enhance their teaching and mentoring skills. "I look forward to continuing work with REU students in the future. I feel that this is a very positive program that further develops the student and the research", one of them pointed out.

In interviews done during the third week of the program, some GMs complained about the lack of technical background of the students and their ability to perform the required research tasks. In most of the cases, this was to be expected, since at the beginning of the program students need more guidance and dedication from the mentor. Later interviews showed improvements with respect to these issues.

Positive Experiences

From the research point of view, the REU experience gives GMs the opportunity to assign time consuming research tasks, such as hardware and software configuration, programming, experimentation, documentation, or results tabulation and plotting, to REU students. As a consequence, graduate mentors can focus on the design of experiments and the analysis of the results. Accordingly, as it is shown in Table III, at least seventy percent of the GMs felt that the work the REU student did helped them to make progress in their research work and could contribute to a future publication.

From the mentoring experience point of view, at least seventy percent of the GMs felt that this experience helped them develop new mentoring skills. Interaction with students through research meetings and social activities gave them a broader perspective on how to define and execute a short-term research plan, how to transmit an idea to the student, how to motivate and engage the student, how to anticipate and deal with unexpected problems, and other general mentoring skills. GMs feel that every Ph.D. student should have the opportunity to experience this role, and in fact they would like to continue in their role as REU student mentors.

Negative Experiences

The main disadvantage from the GM point of view is the time he/she has to devote to the student. That time varies depending on the student's motivation, background, and independent learning skills. However, this time is in most cases well invested as the GM will then benefit from the results of the student's work. We observed that when the GM participates in the project definition, he/she is more committed with the mentoring task. So far, eighty-six percent of the GMs participated in the project definition.

THE STUDENT EXPERIENCE

Similarly, we administered a survey and did several interviews with each of the students. The survey results are shown in Table IV. In most cases, the students felt that the GMs were well qualified and provided them with the information and guidance needed to execute the project successfully. There were, however, two aspects directly related to the goals of the REU program that were given a lower evaluation. The first aspect was that only sixty-seven percent of the students felt that the information provided by the GM helped them to develop skills for independent learning. From the GMs interviews, it was evident that there were different project stages where the students were not able to complete the assigned work. In fact, in some cases, the GM said he performed most of the work in order to advance to the next stage. The second aspect was that only thirty-three percent of the students felt that the GMs gave them useful information about the graduate school enrollment process. However, fifty-six percent of them were unsure about the GM influence. That shows a space for improvement in the way we provide information to GMs about the REU program goals.

Table IV. 2006 survey to evaluate the REU student experience under graduate mentor supervision.

	Yes	Not	Unsure
Do you consider that your graduate student mentor has the required technical background to mentor you?	89 %	11 %	0 %
Are the explanations and directions received from the graduate student mentor clear and easy to understand?	78 %	11 %	11 %
Does the information received from your graduate student mentor help you to perform your work independently?	67 %	22 %	11 %
Does the information received from your graduate student mentor help you to make progress in your research project?	78 %	22 %	0 %
Has the interaction with your graduate student mentor been helpful for you to decide whether or not to enroll in a graduate school?	33 %	11 %	56 %

Positive Experiences

Open lines of communication, as well as GM accessibility and useful guidance are the main benefits perceived by the student. As it is shown in Table IV, the majority (78%) of the students followed the guidance offered by the GM. Similarly, eighty-nine percent of the students believed in the technical capabilities of the GM to guide the project. Therefore, in terms of the research project, students found the GM as an effective facilitator in the process.

We asked students about who they would prefer to be mentored by. The answers foster the participation of GMs in the REU program: eleven percent of them preferred to be mentored only by a FM, thirty-three percent only by a GM, and the remaining fifty-six percent by both the FM and the GM.

Negative Experiences

GMs did not contribute to reach the REU program goal of increasing the enrollment in graduate school. As it is shown in Table IV, most of the students were unsure about how helpful the GMs were for them to decide whether or not to enroll in a graduate program.

THE FACULTY EXPERIENCE

We also interviewed the FMs who participated in the program over the last two years. From the FMs' point of view, the involvement of graduate students in the mentoring process of REU students is beneficial in all respects. FMs believe that REU students greatly benefit from the research experience and knowledge of graduate students, in particular, Ph.D. candidates. FMs also agreed on the fact that graduate students should be mentoring REU research projects directly related to their own research work, so both, the faculty and the graduate student benefit from the REU work. FMs also think that the mentoring experience is very important and valuable for the graduate students, in particular for those who have academic careers in mind.

CONCLUSIONS

Mentoring REU students in a 10-week summer program requires a significant amount of time and constant availability of the mentor. One of the most widely used strategies to address this issue is to involve graduate students as REU mentors. In this paper we analyze the role of graduate students as mentors in a 10-week summer REU program in Computer Science and Engineering run at the University of South Florida for the second year. The paper provides the results of surveys and interviews with REU students, graduate student mentors and faculty mentors. The contribution of the GM toward achieving the goals of the program is also addressed.

Overall, we find that involving graduate students in the mentoring process of REU student is highly beneficial to the REU students, the graduate students, the faculty and the REU program as a whole. How helpful the experience for the graduate student mentor depends on how motivated, engaged, and well prepared the REU student is for the project. A student who does not have these qualifications implies additional work and management skills from the graduate student in order to complete the research project. However, even this type of situation may be beneficial to the GM, as it is a good opportunity to apply and enhance mentoring skills. Here, the experience, advice, and guidance of the faculty mentor are very valuable.

Based on the experience we collected from the previous two years on including GMs in our REU program, we have decided to give the GMs a formal workshop with information on how to help the students learn to work independently, and also information about how to interest the students in pursuing a graduate education. We have also decided that we will increase the number of GMs in the program and also increase their participation in the design and planning of the research projects.

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