

Clemson REU in Computational Number Theory and Combinatorics

Neil Calkin and Kevin James

1. Program History

We began supervising a summer REU program in 2002. We initially received funding for one year through an NSF REU grant. We supervised eight undergraduates for eight weeks. These eight neatly divided themselves into three teams of three and worked on projects related to elliptic curves, partitions and chess. We also invited a couple of our graduate students to attend our daily meetings and interact with the participants. The involvement of graduate students in the research projects worked very well. It was exciting for the graduate students and helpful to the undergraduates and to us.

We enjoyed this so much that we immediately wrote another proposal requesting three additional years of funding and increasing the number of participants to nine. Since the involvement of graduate students worked so well during the initial year, we requested funding to cover the summer salaries of two graduate student mentors. The use of graduate student research team leaders has been very beneficial to the supervisors, the undergrads and graduate students themselves. The undergraduates benefit from having a team leader who is more accessible than the supervisors while the graduate students gain valuable experience in research and in research advising. In fact, several of our summer research projects have continued through to publication and have become a part of graduate students' thesis research.

During our last year of funding under the second grant, we decided that we would like to experiment with a larger group of students. We requested supplemental funding from the NSF to cover the cost of adding more undergraduates and an additional faculty supervisor. We asked David Penniston from nearby Furman University to help us supervise this larger group of students. Unfortunately, we were not notified that our request was granted until the after the 2005 program had begun which made the larger program impossible that year. We were successful in obtaining a new REU grant which will fund our program through summer 2010. The current funding is for two faculty, three graduate students and nine undergraduate participants. During summer 2006, we were able to use the supplemental funding to our previous grant along with the new grant to support twelve

Received by the editor May 11, 2007.

undergraduates, three graduate students and Dave Penniston (and ourselves) as a faculty supervisor. Finally our REU had grown beyond the point which a particular faculty member could closely follow all of the research projects. This made the 2006 program a bit more hectic. However, this program was very productive and we will pursue additional funding to maintain the larger size.

2. Program Goals.

In NSF terms, the main goal of our REU is to help students attain a higher level of independence in mathematical research by taking part in a significant and interesting research project. Put more simply, we want our participants to know firsthand what it is like to be a professional mathematician, so that they can make informed decisions about future careers in mathematics.

We achieve this by including participants into our own research programs and giving them open problems which are important to us and of interest to other mathematicians. We emphasize the importance of the problems which we introduce to participants and state that one of our goals is to publish a paper in a mathematical journal. Although we don't always achieve this lofty goal, the statement of such a goal is extremely important because it causes participants to change their perception of their roles in mathematics. They begin to see themselves as active researchers as well as students. They begin to consider the possibility of engaging in meaningful research and publishing the results, and they begin to believe for the first time that this is an attainable goal. This is a new and exciting possibility for these young mathematicians, and they embrace it eagerly, which creates an exciting atmosphere in which they work harder and learn more than ever before.

While choosing research topics, we look for problems which have some computational aspect. Thus students can start work immediately and they always have work to do even while at a standstill on developing new theorems. We also prefer problems for which we have a plan of attack. We want to give participants every opportunity to be successful in achieving new results.

As a complement to working on their research, participants attend a weekly colloquium series. These lectures are given by mathematicians who have been recognized as leaders in the various fields related to the students' research problems and who have demonstrated the ability to clearly communicate mathematical ideas to audiences of varying levels of mathematical maturity. This not only provides our participants a chance to significantly broaden their mathematical horizons but also provides a networking tool for our students as well as for us. It brings the leaders of our field together with bright and promising undergraduate students. In addition to giving really interesting talks, our speakers typically spend at least a couple of days interacting with our participants. This interaction is a source of great encouragement and inspiration to our participants and is one of the most popular aspects of our REU program (based on anonymous evaluation forms).

We also place great emphasis on the development of communication skills, both oral and written, and a familiarity with the various technologies available for typesetting and presentations. Each participant gives at least two lectures during the program and receives feedback and encouragement on these lectures. We have a workshop on 'how to give a good talk'. During the last week of the program, each research group presents their findings in a talk which is open to all faculty and graduate students. We see vast improvement during the course of the summer

in all participants' abilities relate nontrivial mathematics to an audience of their peers.

We also conduct workshops on writing and each research group submits a report on their summer research in latex format. We collect rough drafts near the end of the program and give the participants some guidance and feedback on their writing. We also encourage participants to continue their research beyond the summer and when appropriate we help them to write up their results and submit them for publication.

We are committed to recruiting a diverse group of participants. Of our 47 past REU participants, 21 are female, 3 are African American, 3 are Hispanic and 1 is physically challenged. In addition, two other African American students were successfully recruited but then were unable to attend the program for personal reasons. We also strive to identify students who would benefit tremendously from our program but might be missed by other REU recruiters. For instance, we have recruited students from smaller colleges and Universities such as UNC-Asheville, Wake Forest, University of Puerto Rico-Humacao, University of Western Alabama, Bellarmine University, Appalachian State University, Bucknell University, Skidmore College, and University of Nebraska-Omaha. We also try to identify non-traditional students who could benefit from our program.

3. Activities

During the first week, our daily schedule is typically as follows. Each day, we give two morning lectures. The purpose of these lectures is to introduce the problems. By the end of the first week, the participants divide themselves into groups of 2 or 3 and choose a problem on which to focus for the remainder of the REU. During the second week, the morning lectures provide a deeper understanding of the selected problems and the significance of these problems while the participants are already making progress in their research. We schedule daily meetings with each research team to discuss their progress and any hurdles they have encountered. We use this time to give advice on how to proceed and to offer encouragement. The students spend the remainder of the day working with their team on their chosen problem.

After the second week, we decrease the frequency of the meetings with supervisors to allow participants more time for independent work. We continue throughout the summer to meet for morning lectures on various topics. Some of these are given by the participants on topics not necessarily directly related to their research problems. These morning meetings lend structure to our days and help ensure that everyone is making the most of our short time together. We then meet with one or two of the research groups and discuss their progress, meeting with each team two to three times per week.

A notable exception to the typical day described above is any day on which we have a colloquium visitor in town. On these days we go to lunch and dinner with our guest in addition to our normal activities. This gives our participants a chance to interact with some really interesting professional mathematicians.

In addition, we host cook on Memorial Day and Independence Day at our homes. Memorial Day is typically very early in the REU and the cook provides an informal setting in which participants can get to know each other and interact with faculty and graduate students.

In previous REUs, participants have organized various outings including hiking, Six Flags over Georgia, Atlanta Braves games, college baseball playoffs, ultimate frisbee, movies, etc. While the dynamics of each years' groups varies, subsequent participants will be encouraged to get to know each other beyond working on research.

4. Judging our Success

As mentioned earlier, publication of journal articles is stated as one of our goals, and although such publications are indicators of success in research, this is not our primary measure of success. We are primarily interested in whether our participants can make an informed decision about continuing their education in graduate school and whether they develop a realistic view of mathematical research. Since our first program, 28 of our past participants have graduated and at least 25 of these have gone on to graduate school. Most of these 25 have gone to grad school in math at Universities like North Carolina State, MIT, Stanford, Dartmouth and University of South Carolina to name a few. However, some chose other areas such as economics, computer science, mathematics education and law school. One of the 3 who chose not to go on to grad school is currently participating in the Teach For America program. She is teaching in an inner city school in Chicago and will likely enter graduate school in math or math ed. after completing this program.

Our participants should learn a good bit of new mathematics while in our program which they do. They should interact with many professional mathematicians which is achieved through our weekly colloquium series. Another indicator of a successful program is the impact of the program on the research of the undergraduate and graduate students and supervisors. Since 2002, our past participants have had 6 journal articles accepted for publication in *Acta Arithmetica*, *Mathematics of Computation*, *Integers* and *Congressus Numerantium*, and there are another 4 papers in preparation. Two of our graduate mentors collaborated on some of these and another graduate student had an article accepted to the *Ramanujan Journal* on research which began as a result of our 2004 REU. Also research begun in our REU program has been the topic of at least 15 conference and seminar talks during the past 5 years.

BOX 340975 CLEMSON SC 29634-0975

E-mail address: calkin@clemsn.edu

E-mail address: kevja@clemsn.edu