

Highlights in Undergraduate Research in Mathematics 1987-2006

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The year 2006 marks the 20th anniversary of the NSF Research Experience for Undergraduates (REU) program. During this period there has been an enormous change in the quantity and quality of research done by undergraduates in the United States. The tenor of the times when REUs began is well illustrated by the following statement made to the National Science Board by Lynn Steen, President of the Mathematical Association of America, in November 1985 [3]:

Research in mathematics is not like research in the laboratory sciences. Whereas undergraduate research can thrive in most chemistry, biology, or physics research laboratories, research in mathematics is so far removed from the undergraduate curriculum that little if any immediate benefit to the undergraduate program ever trickles down from standard NSF research grants. Publication patterns provide vivid proof: hardly every day does one see papers in mathematics jointly authored with students, either graduate or undergraduate. There are a few exceptions—in applied mathematics, in statistics, and in new areas of combinatorial mathematics. But as a general rule, undergraduates can neither participate in nor even understand the research activity of their mathematics professors.

Another statement that perfectly reflects the attitude of the math community had about involving undergraduates in research twenty years ago is the announcement in 1987 in the Notices of the American Mathematical Society of the first REU program sponsored by the NSF [1].

To clarify the range of activities eligible for support under this program, the DMS has formulated the following examples.

- *Direct involvement of a student in a research project operating in an experimental mode, e.g., generating data or working out examples in order to develop conjectures.*
- *Independent study activities where the student is expected to carry out literature searches that indicate the development*

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This article is an expanded version of a joint opening address I and my friend and colleague Aparna Higgins gave at the conference.

over time of the area under study, possibly working through the details in seminal papers. Depth and difficulty of the material could be adjusted to meet the student's background.

The striking thing about this announcement is how modest the expectations are. Today most people who run REUs would consider these activities as the starting point, not the end product of an REU.

To document the growth in interest in fostering research in mathematics by undergraduates in the past 20 years I provide the following list of some of the important events along the way.

1987

- The NSF initiates the REU program. Site awards were granted to Harvey Mudd College, the University of Colorado, Oklahoma State University, the University of Minnesota Duluth, Oregon State University, the University of Tennessee, Rice University and the University of Utah. In addition to REU sites the REU program permits individuals with standard NSF research grants to request a supplement to support a few undergraduate students.¹[2]
- The MAA sponsors an “experimental” contributed paper session for undergraduates at the summer meeting that attracts four speakers. Based on the reaction the session becomes an annual event. (See the article in these proceedings by Betty Mayfield for an historical discussion of the MAA contributed paper session at the summer meetings.)
- Pi Mu Epsilon sponsors a contributed paper session for undergraduates at the summer meeting that attracts 30 speakers. (See the article in these proceedings by Terry Jo Leiterman and Rick Poss for an historical discussion of the PME contributed paper session at the summer meetings.)

1988

- Under the leadership of John Greever the MAA forms a subcommittee on Research by Undergraduates. This committee is responsible for many of the things that appear on this list.
- NSF funds 14 REUs. The University of Washington and Worcester Polytechnic Institute have their first.

1989

- Williams College, Mount Holyoke College and the Rose-Hulman Institute of Technology have their first REU.

1990

- The NSA Director's Summer Program is established. It provides a 12 week REU-like program for top level undergraduates.
- The Council of Undergraduate Research (CUR) establishes a division for mathematics and computer science.
- The AWM Alice Schafer Prize is established. (The prize was not created to recognize outstanding research but over the years research has become the decisive factor in the selection of the winner.)

¹Prior to REUs, which are funded from the NSF Research Division, the NSF Education Division funded a program called “Undergraduate Research Participation” (URP) as far back as the late 1960s. Duluth had one in 1977 and Indiana University and Clemson University had them even earlier.

- Aparna Higgins has her first REU at the University of Dayton.

1991

- The first MAA poster session is held at the joint math meetings in San Francisco. There were 12 posters. The judges pitched in for three cash prizes.
- The MAA committee on Research by Undergraduates sponsors a panel on “Models for Undergraduate Research” at the joint meetings.
- The AMS and the MAA jointly sponsor a three part special session for research papers by undergraduates that features 22 talks representing the work of 54 students.

1993

- The MAA and CUR sponsor a panel discussion on research by undergraduates at the joint meetings in San Antonio.

1994

- The MAA sponsors the first minicourse on undergraduate research at the joint meetings at Cincinnati.
- The MAA and CUR sponsor the second poster session on undergrad research with 19 students participating. The poster session now becomes an annual event.
- The AMS sponsors a four part special session for research by undergraduates at joint meetings with 38 talks representing the work of 68 students.²

1995

- The AMS sponsors a three part special session for research by undergraduates at joint meetings in San Francisco with 39 talks representing the work of 54 students.
- Aparna Higgins gives the first Project NExT course on undergraduate research. This course becomes an annual event and draws 25 or so participants each year.
- The MAA, AMS and SIAM jointly establish the Morgan Prize for Outstanding Research by an Undergraduate.
- The poster session at the joint meetings has 13 entries.

1996

- The Notices of the American Mathematical Society begins identifying talks by undergraduates at the joint meetings in the program announcement. There was not a special session for research by undergraduates but six undergraduates spoke at contributed paper sessions at the joint meetings in Orlando.

1997

- The MAA sponsors a minicourse on undergraduate research at joint meetings at San Diego.
- The AMS sponsored three special sessions on undergraduate research with 22 presentations representing the work of 29 students.
- Fifteen papers are presented in a contributed paper session on establishing and maintaining undergraduate research programs in mathematics.

²Two of the student speakers, Dan Isaksen and Darren Narayan, are faculty participants in this conference.

1998

- 171 undergraduate students attend the joint meetings at Baltimore.
- Twenty people contribute papers in an MAA session on establishing and maintaining an undergraduate research program.

1999

- The number of students involved in the poster session is a record 68.
- The National Security Agency and the AMS sponsor a conference on summer research programs in mathematics for undergraduates. The proceedings are published by the AMS (see <http://www.ams.org/employment/REUproceedings.pdf>).
- The AMS and MAA sponsor a special session for undergraduates at the joint meetings in San Antonio.
- The MAA minicourse on getting undergraduates involved in research at joint meetings becomes annual event.

2000

- 140 students are involved in the poster session at Washington D. C. In subsequent years the number is limited by the size of the room available as demand exceeds the space available. The poster session annually becomes one of the best attended events at the joint meetings.
- The AMS sponsors a four part special session on research by undergraduate students with 38 talks representing 70 students at the joint meetings.
- The MAA sponsors a special session for professors on how to establish and maintain a research program for undergraduates.

2001

- The MAA includes in its Mission Statement: “We support research, scholarship, and its exposition at all appropriate levels and venues, including research by undergraduates.”
- The poster session has 77 posters representing the work of 148 students with fifteen \$100 prizes.

2002

- At the joint meetings in San Diego SIAM sponsors a minisymposium on undergraduate programs and research projects in applied and computational mathematics.
- Project NExT organizes a swap session on involving undergraduates in research at the San Diego meetings.
- The following events become standard at all successive annual joint mathematics meetings:
 - A special session for research by undergraduates;
 - A contributed paper session for professors on involving undergraduates in research;
 - A poster session for research by undergraduates.

2003

- The poster session at the joint meetings has 200 participants.

- With funding from the NSF, the MAA initiates a minigrants program for conferences that focus on talks by undergraduates.
- With initial funding from the NSA to support 8 students, the MAA establishes a national REU with emphasis on providing opportunities for underrepresented groups. With subsequent support from the Moody's Foundation and the NSF, the program grows to 52 students in 2006.
- For the first time SIAM joins the AMS and MAA as cosponsor of a special session for research by undergraduates.

2006

- 377 undergraduates attend annual joint meetings at San Antonio with 44 of them giving talks.
- The AMS, MAA, AWM, CUR and the EAF (Educational Advancement Foundation) combined for 37 \$100 prizes for the poster session.
- Michael Dorff from BYU receives \$1.28 million from the NSF to provide 12-15 minigrants to fund faculty and 2-4 undergraduate students during the academic year to work together on research.
- The MAA sponsors its 20th annual contributed paper session at Mathfest in Knoxville. Sixty students give talks in six sessions. Twelve prizes are awarded by CUR, SIAM and the MAA.
- Pi Mu Epsilon sponsors 43 students talks at Mathfest.

Although there are many reasons for the dramatic rise in the number of undergraduates doing research in mathematics, I wish to conclude by identifying the ones I feel are the most significant.

- **NSF and NSA funding**

By a far margin, the generous support from the NSF and the NSA for summer REUs and REU-like programs has been the impetus for nearly all other efforts.

- **The Council on Undergraduate Research**

The lobbying efforts by the Council on Undergraduate Research (CUR) were largely responsible for the NSF creating the REU programs. CUR has provided some professional development opportunities for mathematicians who wish to involve undergraduates in research.

- **MAA minicourses**

Over the past dozen years several hundred people have taken the MAA minicourse on how to involve undergraduates in research. Most of these were offered jointly by Aparna Higgins and the author.

- **MAA poster session**

The MAA poster session at the joint meetings has become a showcase event for undergraduate students to exhibit their work.

- **Project NExT**

For a dozen years Aparna Higgins has offered a very popular Project NExT course on getting undergraduates involved in research. About 300 new faculty have taken the course.

- **MAA undergraduate conferences**
Since 2003 the MAA has provided funding through an NSF grant for regional conferences that focus on research by undergraduate students.
- **Pi Mu Epsilon**
For many years Pi Mu Epsilon has sponsored regional conferences and paper sessions at Mathfest dedicated to undergraduate research.
- **MAA paper session at Mathfest**
The MAA has sponsored a student paper session at Mathfest for 20 years.
- **NSA Director's Summer Program**
The NSA Director's Summer Program, now in its 17th year, is one of the largest research programs for undergraduates in existence. Moreover, it is one of the few that provides a research opportunity for students in the summer prior to their entering graduate school.
- **VIGRE programs**
Several major Ph. D. granting institutions have run REU-like programs as part of their VIGRE program.
- **Pipeline effect**
REUs have been around long enough that REU alumni are now providing research opportunities for their own students.
- **Deans are demanding it**
More and more Deans are demanding that faculty in all disciplines provide research opportunities to undergraduates. This is even the case at many schools where faculty have very high teaching loads. It was commonplace for math departments to be exempt from this pressure but this is becoming less so.

With Lynn Steen's statement made in 1986 given at the beginning of this article in mind, I wish to close this essay with my own made at the 2006 AMS-NSA Conference on Promoting Undergraduate Research in Mathematics.

"Under the right circumstances, undergraduates CAN participate in mathematics research."

References

1. New program for undergraduates, Notices Amer. Math. Society 34 (1987) 297-298.
2. Undergraduate students participate in research, Notices Amer. Math. Society 34 (1987) 911-912.
3. Lynn A. Steen, Restoring scholarship to collegiate mathematics, FOCUS, 6:1 (1986) 1-2, 7.

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