

CURM – Promoting Undergraduate Research in Mathematics

Michael Dorff

Abstract The national Center for Undergraduate Research in Mathematics (CURM) was established in 2006 with funding from NSF to promote academic year undergraduate research in the mathematical sciences by training faculty members as mentors for undergraduate research projects, having these faculty members mentor undergraduate students in small research groups that work during the academic year at their own institution, and preparing undergraduate students to succeed in graduate studies in mathematics

1 Introduction

In order to help more students and professors have a successful experience in doing undergraduate research in mathematics, the national Center for Undergraduate Research in Mathematics (CURM) was established in 2006 with NSF grants totaling over \$2.5 million. CURM promotes academic year undergraduate research in the mathematical sciences by:

- training faculty members as mentors for undergraduate research projects;
- having these faculty members mentor undergraduate students in research groups that consist of 2-5 students who work together as a team on a research project during the academic year at their own institution; and,
- preparing undergraduate students to succeed in graduate studies in mathematics.

To help achieve this, CURM administers mini-grants annually to 15 professors working with about 45 undergraduate students on research during the academic year at various institutions across the U.S. These mini-grants include a \$3000 stipend for

Michael Dorff
Brigham Young University, Department of Mathematics, Provo, Utah 84602
e-mail: mdorff@math.byu.edu

each participating undergraduate student, a \$6000 stipend for each professor to reduce her/his teaching load in order to adequately mentor the group of students in research, and \$250 in supply funds for each research group. Also, there is an annual summer workshop to train the professors in mentoring skills, and there is a culminating spring research conference in which the undergraduate students present their research, learn more about mathematics and opportunities available to those who study mathematics, and information to prepare them to attend and succeed in graduate school.

For the past four years, CURM has awarded mini-grants to 64 professors (41% female, 19% minority) from 54 different institutions to work with 195 undergraduate students (54% female, 29% minority). During the first three years of CURM (the years that have been completed), the 147 undergraduate students have written 60 joint research papers, 15 of which have been published in research journals such as *Discrete Math*, *Journal of Difference Equations*, *Journal of Pure and Applied Math*, *International Journal of Biomathematics*, *Applied Probability Trust*, and *Involve* while some of the other papers are currently being refereed. In addition, CURM students have given 123 single or joint conference presentations, 35 poster presentations, and have received 29 awards for their presentations or research. Finally, the data indicates that at institutions participating in the CURM program, about 18% of the math majors go on to graduate school while 63% of the CURM students at these schools go on to graduate school. More information about CURM can be found at its web site <http://curm.byu.edu>.

2 CURM

The benefits for students who participate in undergraduate research in a STEM field are significant as reports have shown ([4], [5], [10], [11]). These benefits can be summarized to include gains in knowledge and skills, academic achievement and educational attainment, professional growth and advancement, and personal growth [9]. For students from underrepresented groups, a research experience with an experienced faculty mentor is positively correlated with improvements in students' grades, retention rates, and motivation to pursue and succeed in graduate school ([3], [6], [8]). Generally, there are two types of undergraduate research projects in mathematics: multiple-week summer REUs and individualized academic-year projects at the student's own institution. CURM offers another model.

2.1 *Mini-grants*

CURM offers 15 mini-grants each year to faculty mentors who are accepted into the program. These mini-grants consist of training and financial support for undergraduate research groups consisting of 2-5 undergraduate students. These groups start

during the fall semester and continue through the academic year. Typically, the students commit to work 10 hours/week at their own institution on the research project for two semesters. The entire group meets at least one hour a week and the students meet and work together at least three hours a week. The rest of the time each individual student works on his/her research problem. CURM offers a \$3000 stipend for each student in the group (\$1000 to be paid at the beginning of the fall semester, \$1000 to be paid at the beginning of the spring semester, \$500 to be paid after the student presents at the spring research conference, and \$500 to be paid after submitting the final research paper/report). By having students work together in groups, they tend to motivate each other and they also learn to become more independent of the faculty mentor. Of course, the faculty mentor needs to be actively involved with the group. However, many of them are at institutions with a teaching load of 3-4 courses/semester. Hence, CURM provides \$6000 for the professor to buy out at least one course from his/her teaching load during the academic year in order to free up time to spend working with these mentored groups.

2.2 Summer training workshop

Before the faculty members begin mentoring their students in the undergraduate research group, they attend a two-day summer workshop. The purposes of this workshop are to discuss effective approaches in working with undergraduate students in academic year research and develop a rapport among the professors. There are specific presentations and discussions lead by the CURM directors. These include such topics as developing a manageable timeline for academic year undergraduate research, how to get started mentoring undergraduate students in research, potential pitfalls and overcoming them during the mentoring journey, working with group dynamics among students with different backgrounds and skills, and helping students develop independence in doing research. Some of this has been published in papers co-authored by various CURM directors and CURM professors ([1], [2], [7]). Finally, there is a CURM Facebook page that the professors are invited to join to facilitate discussions about their experiences.

2.3 Spring research conference

Having the undergraduate students present their research in a supportive environment is very beneficial in motivating them to be consistent in their research, to feel the excitement of the mathematical community, and to prepare for graduate school. Therefore, we organize a CURM research conference that each student participant and faculty mentor attends. The conference consists of activities to motivate and intellectually stimulate students to continue to study mathematics and prepare for

graduate school, and 20-minute sessions in which the student participants present their research with written feedback and guidance from two CURM professors.

In the past, this conference has been held at Brigham Young University (BYU) in March. We have brought in three keynote speakers known for giving interesting mathematical talks appropriate for undergraduate students, such as Bob Devaney, Joe Gallian, Aparna Higgins, Colin Adams, Laura Taalman, Tony DeRose, Dave Kung, and Frank Morgan. Also, we have created the *What is . . . ?* series in which professors, who are known for being excellent teachers and being able to connect with undergraduate students, give a 30 minute presentation on advanced topics at a level suitable for the students. Topics have included hyperbolic geometry, operations research, minimal surfaces, coding theory, cryptography, and dynamical systems. There have been panel discussions on attending graduate school in mathematics with panelists. To help students build a sense of belonging to the mathematics community, there were also social activities such as a banquet, a hike, and a reception with games.

2.4 Research reports

Having the undergraduate students write up a paper about their research is very beneficial in both motivating them to be consistent in their research and in preparing for graduate school. In the research paper, we encourage the group to not only describe their research but also propose some open problems in the research area that they would have worked on if they had had more time. Thus, the paper is not only a tangible end product for the initial research group but is also a written starting resource with a set of research problems for future undergraduate students who are recruited to work with that professor on research. We require all groups to submit to CURM a final written research paper at the end of May of the academic year. We encourage the CURM professors to have their undergraduate students submit their research papers to refereed journals for publication if appropriate.

3 The effectiveness of the CURM program

CURM has a tremendous effect upon undergraduate students, their professors, and their departments and institutions. It has been fantastic to witness the indirect benefit of changing the practices and culture in mathematics departments and in some cases even at institutions as groups have participated in the CURM program. As CURM students and professors have shared the results and experiences in doing undergraduate research (e.g., presentations of their research in the department, awards from their institution or from conference presentations, university newspaper articles, acceptance to graduate school, etc.), other students have listened and have become interested in doing research. This has resulted in some departments creat-

ing new courses in which students now can get academic credit for doing research allowing a professor to count that research as part of his/her teaching assignment. In some places, the dean has been impressed with the results of the CURM research group and has offered internal funds to the CURM professor to continue to work with undergraduate students on research after the CURM year is over. At two minority-serving institutions, Jackson State University and California State University – Channel Islands (CSUCI), the administrations have been so impressed with the CURM program that they have introduced new university-wide programs promoting undergraduate research in all disciplines based upon the CURM model. Below are some remarks by previous CURM participants on the effect the CURM program has had.

3.1 Undergraduate Students

CURM has opened many doors for my future. It encouraged me to apply for a summer 2008 REU [got accepted into one, and attended it]. . . If it weren't for CURM, I wouldn't be where I am today; I wouldn't know what it meant to do research, and I wouldn't be applying for graduate school.

Amy Stockman, Concordia University

At my institution, students are mainly Hispanic origin. I have seen many of my students struggling at school because they had to work outside of the classes to support themselves or their families. This has tremendous impact on their academic achievements. Most of them even do not think about continuing on higher education . . . CURM provided the hand I needed to extend to my two female students . . . both of them will be the first generation who will be going to a graduate school among their family members.

Gulhan Alpargu, California State University–Fullerton

[I want to mention] how important CURM grant was for me and my students here. Couple of years ago there were [hardly any] students thinking of maybe applying to a graduate program in the future, but now we have at least 2-3 per year that are actually taking the GRE tests and applying for graduate schools.

Nicoleta Tarfulea, Purdue University–Calumet

3.2 Faculty and Institutions

Because of the CURM grant, I was able to work with a large number of students (7 total, while only 2 were supported by CURM). All it took was this one year of the CURM grant to fan the fire, and our department has begun to foster an environment that encourages undergraduate research. This coming year there will be 4 professors working with students or groups of students on research projects.

Joan Lind, Belmont University

After learning of my CURM group, the Dean of Faculty at CSUCI introduced a pilot undergraduate research program where faculty in any discipline may apply to receive teaching credit for offering a course where students work on research projects. More recently, the

Dean has established a Student Research Steering Council to embed student research experiences across the curriculum. In other words, institutionalization of undergraduate research at my university has been sparked by my CURM experience.

Kathryn Leonard, California State University–Channel Islands

Acknowledgements CURM has been funded by NSF grants DMS-0636648 and DMS-1148695 and by Brigham Young University.

References

1. B. Bailey, M. Budden, M. Dorff, U. Ghosh-Dastidar, "Undergraduate Research: How Do We Begin?" *MAA Focus*, **29** no. 1, pp. 14-16, 2009.
2. B. Bailey, M. Budden, U. Ghosh-Dastidar, "Practical Tips For Managing Challenging Scenarios in Undergraduate Research," a summary of ideas discussed by a group of faculty participating in the 2008 Center for Undergraduate Research in Mathematics (CURM) Workshop. MAA online column *Resources for Undergraduate Research*, no. 3, Dec. 2008. Available at http://www.maa.org/columns/resources/resources_12_08.html.
3. A. Barlow, M. Villarejo, "Making a difference for minorities: Evaluation of an educational enrichment program," *Journal of Research in Science Teaching*, **41** pp. 861-881, 2004.
4. R. S. Hathaway, "The relationship of undergraduate research participation to graduate and professional educational pursuit: An empirical study," *Journal College Student Development*, **43** pp. 614-631, 2002.
5. A.-B. Hunter, S. L. Laursen, E. Seymour, "Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development," *Science Education*, **91** pp. 36-74, 2006.
6. J. T. Ishiyama, V. M. Hopkins, "Assessing the impact of a graduate-school preparation program on first-generation, low-income college students at a public liberal arts university," *Journal of College Student Retention*, **4** pp. 393-405, 2002.
7. K. Leonard, "Adventures in Academic Year Undergraduate Research," *Notices of the AMS*, **55** no. 11, pp. 1422-1426, 2008.
8. B. Nagda, S. Gregerman, J. Jonides, W. von Hippel, J. Lerner, "Undergraduate student-faculty research partnerships affect student retentions," *Review of Higher Education*, **22** pp. 55-72, 1998.
9. J. M. Osborn, K. K. Karukstis, "The benefits of undergraduate research, scholarship, and creative activity," *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*, Council on Undergraduate Research, Washington, DC, pp. 41-53, 2009.
10. E. Seymour, A.-B. Hunter, S. L. Laursen, T. DeAntoni, "Establishing the benefits of research experiences for undergraduates: First findings from a three-year study," *Science Education*, **88** pp. 493-534, 2004.
11. L. Sharp, B. Kleiner, J. Frechtling, *A Description and Analysis of Best Practice Findings of Programs Promoting Participation of Underrepresented Undergraduate Students in Science, Mathematics, Engineering, and Technology Fields*, Report No. NSF 01-31, Arlington, VA: NSF, 2000.