

# Carleton and St. Olaf Colleges' Summer Mathematics Program

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The Carleton and St. Olaf Colleges' Summer Mathematics Program<sup>1</sup> began in the summer of 1995. Each year we admit eighteen lower-division students contemplating a major in mathematics or who have just declared a major in mathematics and who demonstrate some of the skills and a desire to continue on to a graduate degree in the field. By selecting lower-division students, we hope to provide these women with support and direction as they make choices critical to their future and to make certain that they have enough time (two or three academic years) to structure their undergraduate experience in a way that will best prepare them for graduate study.

The National Science Foundation has been the primary source of funding for this program since its inception with important supplemental funding contributed by the National Security Agency. The program is directed by Deanna Haunsperger, Stephen Kennedy, and Gail Nelson of Carleton College, and Jill Dietz of St. Olaf College. A former director, Laura Chihara, formerly of St. Olaf College, played an instrumental role in the development of the program.

## The Problem

The numbers are familiar to everyone in mathematics: between July 1, 1994 and June 30, 1995 U.S. colleges and universities awarded 20154 Bachelor's degrees in mathematics. Of these, 9061 (45%) went to women<sup>2</sup>. In that same period 1226 Ph.D.s were awarded (fall count), of these 280 (23%) went to women<sup>3</sup>. In this decade the percentage of

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<sup>1</sup>The program's Webpage is located at [www.mathcs.carleton.edu/smp/](http://www.mathcs.carleton.edu/smp/).

<sup>2</sup>*Notices of the American Mathematical Society*, vol. 44, no. 8, p. 926.

<sup>3</sup>*Notices of the American Mathematical Society*, vol. 43, no. 8, p. 850.

women among U.S. citizen mathematics doctoral recipients has been between 24 and 29. The growth in this percentage over the last twenty years is due, about equally, to increases in the number of female doctorates and decreases in the number of male.

Why do so few women (relative to men) pursue advanced degrees in mathematics? Although definitive studies on this problem have not yet been done, anecdotal evidence points to several causes. Often, talented women who are drawn to mathematics find it difficult to believe that they can have effective careers in the field. Few of their professors are women. The male students in the class seem to get more attention from the instructor, and, for whatever reason, seem to dominate the classroom discussions with their questions and responses. Most students demonstrate a lack of awareness about women mathematicians. Thus, women studying mathematics often have to deal not only with the difficulties inherent in the subject itself, but with the psychological and emotional problems caused by studying in such an environment.

While not all women students may be so affected, many are. In a 1984 survey of American graduate students in science, engineering, and medicine at Stanford University, all women and an equal number of randomly selected men in these fields were questioned. A comparison of the male and female students' "always" or "often" responses to the following statements illustrates gender differences in self-esteem. How often do you: fear speaking will reveal inadequacy (9% of males, 33% of females); question if you can make it in your field (9% of males, 24% of females). To cite a local example, the women who have participated in the Carleton and St. Olaf Summer Program for Women are among the strongest undergraduate mathematics majors in the country, yet many of them reported in post-program evaluations that, before entering the program, they had doubts about their abilities to succeed in a graduate program. It is a tragedy that some of our brightest young women are being lost to mathematics because of such factors.

### **The Summer Mathematics Program**

Students in our four-week program participate in two classes which meet on alternate weekday mornings from 8:30 to noon. We encourage the instructors to try new ideas, to teach courses the students would otherwise not see, and to challenge these extremely talented young women. The students each year report in post-program evaluations that they had been asked to do things they they did not believe they could do, but with the support of the faculty and of their peers, they had struggled to accomplish something difficult and meaningful.

We keep the students very busy: in addition to the coursework there is a twice-weekly colloquium series. Highlights have included Mary Ellen Rudin's visit (A History of Women in Mathematics), Marge Murray's visit (An Introduction to Clifford Algebras), and our annual visit from Joe Gallian (Breaking Drivers' License Codes) who not only gives a lovely colloquium, but also tells the students about the opportunities available to them in REUs. We always have talks by several local faculty, and each year we have a speaker from the National Security Agency and other non-academics.

In addition to the colloquium series, there are weekly panel discussions intended to give the women some guidance as they plan the rest of their education. The first discussion is about completing an undergraduate math major. We tell the students what courses one needs for graduate school and what kinds of extra-curricular activities they might seek out: the Budapest Semester, the MASS Program, Research Experiences for Undergraduates. The second discussion is about careers that use mathematics, usually at the B.A. or M.A. level. We bring in four or five women who use mathematics in their work. We have had people in operations research, actuaries, a statistician from the Mayo Clinic, computer programmers, business consultants, a computer security expert, and more. The third discussion is about how to apply to and succeed in graduate school; we always have current graduate students and graduate faculty present to act as resources. The final discussion is about the special difficulties and joys of being a woman in a scientific field.

Around and through it all, we weave outings and social activities: at least one picnic per week, movie nights, canoe trips, hikes, the Science Museum. Every weekend features at least one organized excursion. One evening each week we have recreational problem solving. One night each week Deanna visits the dorm lounge for "Deanna chat," a time for her and the students to check that everything is going smoothly. The program closes with a banquet celebrating success and honoring the participants; farewells are difficult for the women, many of whom found long-sought-after sisters in mathematics.

Students do not receive course credit for, or grades in, these courses. Each student does receive, at the close of the program, written evaluations from her instructors of her performance and accomplishments.

The community that develops amongst these students, teaching assistants, and faculty is reinforced through an electronic list-server which we maintain. Participants from past years still update us and each other on their lives through this list-server. Lifelong friendships and

networks have been formed. The directors plan to hold a reunion of participants at the winter Joint Meetings.

### **The Students**

We choose students who have taken a course in linear algebra and a small number of subsequent theoretical courses and who have demonstrated some interest in mathematics and gained some mathematical maturity from their courses. They are also at a level where professors are able to identify them as potentially benefitting from such a summer program. Typically, these students have just completed their sophomore year at a college or university. The students are selected based upon information contained in: two teacher's evaluations of the student's potential for advanced work in mathematics; the student's grades in mathematics to date; and the student's motivation and interest in mathematics, as evidenced by the personal essay she writes. The directors select students to achieve a good balance of academic backgrounds, considering such things as their home institutions and the classes they have completed. Applications are solicited through advertisements in the journals of the professional societies (FOCUS, AWM Newsletter, Math Horizons) and by mail sent to the chairs of all U. S. mathematics departments. We average 119 applicants per year, of whom 50 to 60% are very well qualified for our program. It is quite difficult to narrow our choices to the 18 we can accept.

### **The Faculty and Teaching Assistants**

The courses are staffed by women who are active professionals and outstanding teachers. Each of them has thrown herself into the program, and given of her time and energies in ways that we did not imagine would happen, and would never dare ask of anyone. Each has described her time in the SMP to us as the most fulfilling, rewarding teaching experience of her life. Those instructors (with affiliation and course title) have been: Judy Kennedy (University of Delaware; Dynamical Systems), Gail Nelson (Carleton College; Knot Theory), Tami Olson (Michigan Technological University; Applied Functional Analysis), Laura Chihara (St. Olaf College; Algebraic Coding Theory), Karen Brucks (University of Wisconsin at Milwaukee; Low-Dimensional Dynamics), and Rhonda Hatcher (Texas Christian University; Game Theory).

The teaching assistants are alumnae from an earlier SMP, whose experience with upper-level mathematics courses and the SMP itself has been much appreciated. The teaching assistants help the students with mathematical problems, live and dine with the students, help

organize outings, cheer the sad, and build an *esprit de corps* amongst the girls.

The faculty and teaching assistants are expected to, and do, serve as role models of professionalism and dedication to mathematics. It is hoped that the faculty will also lay the foundation for a long-term mentoring relationship with each student in the program. This is happening: the students from the first years of the program write to us and to their instructors for advice about courses and graduate school.

### The Outcome

Our 18 young women mathematicians immerse themselves in mathematics, living and working in a supportive community of women scholars (undergraduates, graduates, and faculty) who are passionate about learning and doing mathematics. Our intentions for them are three-fold: to excite them about mathematics and mathematical careers, to provide them with some of the tools they will need to succeed in a mathematical career, and to connect them to a network of fellow female mathematicians. We have been successful, as measured by the participants' post-program evaluations and a survey conducted in 1998, in achieving all of these goals.

The students, faculty, teaching assistants, and directors all confess to being profoundly influenced by the program. The following quotes are culled from student's post-program evaluations:

This experience has revived my mathematical soul and charged me up.

Thank you for an awesome experience. It is something I will remember for the rest of my life.

This has been, by far, the most exciting and **fun** experience in math I've ever had.

The program has certainly confirmed my desire to major in math at the undergraduate level, and it has revealed more options than I previously expected for graduate study and an eventual career.

But the more I listen and learn of myself, I know that I can't stop after college and I won't stop until I feel that I've learned enough. And when I come to your grad school panel in a few years I'm gonna tell some really good stories.

and to connect with such brilliant and fun women was awesome!

I found it inspiring and informative to be around so many knowledgeable people with whom I could easily connect and communicate. The information and contacts that I have gained are invaluable. Everyone should have something like this at some point (sooner rather than later).

1995	4 Budapest/MASS program 7 REU or summer research 2 Other women's program
1996	1 Budapest 8 REU or summer research 1 Women's program 1 NSA Summer Research
1997	1 Budapest 7 REU or summer research 1 NSA Summer Research
1998 (so far)	5 Budapest 8 REU or summer research 1 Women's program

**Table 1.** SMP alumnae, further enrichment.

The students return to their home institutions eager to plunge into their studies. They have a clearer idea of what mathematics is and how to organize their future plans. Their increased awareness of various topics within mathematics have led many to give talks in their home departments on the mathematics that they learned in the summer program. Most have already participated in REUs, the Budapest Semester, or other enrichment programs (Table 1). All who have done so acknowledge being much better prepared to succeed at, and benefit from, those programs than they otherwise would have been. More important than the knowledge and renewed excitement for mathematics, each of the students has gained confidence in her ability to do mathematics.

It challenged me, but I was able to work through the proof, I really put my heart into it—and I loved it. It was not only good for me alone, but it was so special to have a class full of people who could handle this level of

But now, given this opportunity, I'm excited for school to start in the fall and I'm excited that I am a smart and intelligent math student. Really I am. And most of all, I don't need to prove it to anyone - just to myself.

[Studying mathematics in a group of women students] is the best! People explained things so that others would understand, and people kept telling each other, "Good call," "great idea," or "you're brilliant." You don't hear that studying with guys. It is very reassuring to discover that almost everyone else has the same insecurities and self-doubts and when you realize everyone else's are unfounded, it starts to chip away at your own. A very positive experience.

Most of all the program has given me the confidence that I can succeed in math, both as a student and as a woman. I have proved things which I had doubted I could.

The satisfaction one derived from finally completing that proof they had been working on for a week was tremendous. It taught you that you could do things on your own.

The [SMP] has given me the confidence, the mathematical foundation, and the desire to propel myself through advanced studies of mathematics. It has been an immense force driving all of us on to higher plains of mathematics. The courses and people contributed to an environment which has nourished and developed our mathematical souls.

This confidence building is central to the mission of the program. All of these students, and most of the other one hundred who applied, are intellectually capable of achieving an advanced degree in mathematics. Something other than intellectual capacity prevents many women from pursuing one. Heightened self-confidence and a supportive network of colleagues and mentors are two factors which we hope will prevent young women from dropping out. These students return to their home institutions knowing that women can and should be doing mathematics. They will not only be supported by this knowledge, but they also will carry the message back with them to influence their peers and their teachers.

Table 2 gives up-to-date information on where the SMP alumnae went after graduation (or, in the case of those not yet graduated, where they plan to go).

	1995	96	97	TOTALS
Grad school in math or related field	7	11	13	31
Career in math-related field	8	4	0	12
Other grad school or career	3	3	0	6
Undecided	0	0	3	3

**Table 2.** Post-graduation outcomes/plans for SMP alumnae.

### Conclusion

We have an impact on the lives of the young women who come to our program – we see the increased confidence, enthusiasm, knowledge, and mathematical sophistication. We see the electronic messages they post on the program’s list-server to let us and each other know what is happening in their lives – mathematical and otherwise. It is less clear to us how to measure this effect. We can never know how many would have gone on to productive mathematical careers without us – given the talent level some certainly would. We won’t know for some time how long and how far the impetus we give will sustain them in the face of adversity. We do believe that we are making a difference though: last week Cathy (SMP 95) told us that she was headed off to a top-twenty mathematics department to get her Ph.D. She had followed up her SMP experience with two other summer experiences, including an REU. But, she said, neither of those programs had the kind of transformative effect on her that this one did. “If I hadn’t been in your program, even with those other two programs, I wouldn’t be going to grad school in math.”

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