

WAM: Fostering Excellence in Mathematics Research for Twenty-Five Years

Evelyn Lamb

Karen Uhlenbeck, professor emerita at the University of Texas at Austin, can remember the first time she ran into another woman in a math department. It was in the 1980s, more than a decade into her career, at her fourth academic position since graduating. When she earned her PhD in 1968, she was one of very few women who were entering the tenure track at a research-oriented math department. She kept her head down and focused on research and, despite barriers such as anti-nepotism rules that made it difficult for her to get a position at the same institution as her husband at the time, forged a successful research career. "The assumption was that things would get better," she says. But in the early 1990s, she and others who had been part of the influx of women into math departments in the 1970s realized they were still the youngest women in their departments. "A lot of us who were not very involved in women's issues looked around and said, 'Something needs to be done.'"

In 1993 Antonella Grassi, then a postdoc at Duke University, organized a mentoring program for women in mathematics at the Mathematical Sciences Research Institute (MSRI). The next year, the program moved to the Institute for Advanced Study (IAS) campus in Princeton, New Jersey. Uhlenbeck and Chuu-Lian Terng, then a mathematician at Northeastern University in Boston, organized the program. Twenty-five years and over 1000 alumnae later, the Women and Mathematics program (WAM) at the Institute for Advanced Study is being recognized with the 2019 AMS Mathematics Programs that Make a Difference

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Dusa McDuff, a program organizer for WAM, talks with program participants in the IAS cafeteria.

Award. "It's a wonderful recognition," IAS director Robbert Dijkgraaf says. "We're very happy about it."

WAM began under the auspices of the Park City Mathematics Institute (PCMI), a summer program run by the IAS that brings mathematicians and mathematics teachers from various backgrounds and geographical areas together to study and exchange ideas. PCMI was founded in 1991, and Uhlenbeck was one of the founders. Because of that connection, it made sense for the women's program to be part of PCMI. In the early years, women students who had been accepted into PCMI would be invited to a summer school at the Institute in May, before PCMI itself, to meet each other and get an introduction to the mathematics that would be the focus of the program.

WAM has changed and evolved over the decades. After a few years, WAM separated from PCMI in order to remove the restriction that participants must attend PCMI as well. For many years, WAM was a two-week program. Today, due

to both budgetary and scheduling considerations, it is one week long, hosting about 60 participants at various stages in their mathematical education and career paths, from advanced undergraduate students to postdocs. Instructors and guest lecturers participate as well. The two lecture series and related problem sessions form the core of the program, with other programming such as outreach events and career panels as an important focus. “We have a good mix of academic and social interactions,” says Michelle Huguenin, the administrative program manager of WAM.

Although there was some resistance among mathematicians to the idea that a program for women in mathematics was necessary, the IAS under then-director Phillip Griffiths was supportive, providing funding and generous administrative assistance. “When you’re offered [something] like that, you don’t turn it down,” Uhlenbeck says. “They were terrifically supportive all along.” Currently, funding for WAM comes from both Princeton University and the National Science Foundation.

Dijkgraaf notes that WAM is an important part of the IAS mission to foster excellence in mathematics research. Mathematics is a field that “belongs to all of us,” he says. Or at least it should. When, due to race- or gender-based discrimination, entire groups of people are forced to overcome barriers not present for white men or are excluded from mathematics entirely, the field as a whole suffers. “It is extremely important, I think, that we bring a maximum of diversity to math,” Dijkgraaf says. From the point of view of mathematics, it is a self-serving goal—a larger talent pool means better mathematics. But of course, access to a quality mathematics education is a question of equity as well. Mathematics is one of the most widely taught subjects across the world, and, for better or worse, it is a gatekeeper for many other classes. Students with strong math backgrounds who can demonstrate facility in learning new mathematics have a wide variety of career paths open to them.

Much of the focus at the IAS is on giving outstanding individual researchers the freedom to work on the questions that most fascinate them without teaching obligations or pressures from commercial interests or funding agencies. But WAM and PCMI make their marks differently. They are part of broadening the reach of the IAS beyond the lucky few who get to spend years strolling through the campus’s serene woods and settling in for lunches at its legendary dining hall. Those programs “maximize our impact on the mathematical community,” Dijkgraaf says. Though IAS is a relatively small institution, its historical importance in the mathematics community allows it to, as Dijkgraaf puts it, “punch a little bit above our weight.” The Institute’s investment in a program designed to address the issue of women’s underrepresentation in mathematics makes the statement that the problems women face in mathematics

education and career development are worth understanding and combatting.

Continuing Importance

From the beginning, the need for a program like WAM was obvious to Uhlenbeck and other women mathematicians of her generation. “Everybody my age knew there was a problem. People reminded you of it every day,” she says. “But it wasn’t clear that hanging around with other women would solve the problem.” She and other women mathematicians wanted to show that women consciously grouping and working together could help students get ahead and find a place in the mathematics research world.

Dusa McDuff, professor of mathematics at Columbia University and Barnard College and current chair of the WAM steering committee, is a few years younger than Uhlenbeck but also graduated at a time when very few women went into math research careers. When she was starting her career, “there were some women mathematicians, but there were none I knew,” she says. She was aware of some historical women in mathematics but never had female mathematician role models to look up to. “Having an existence proof is something, but it would be nice to actually know somebody.”



A WAM discussion session.

Open prejudice against women in mathematics is much less common than it used to be. It is no longer condoned by university policies, and mathematicians, whether male, female, or nonbinary, are increasingly likely to speak up when they encounter it. But there are still lingering prejudices in attitudes about who can be taken seriously as a mathematician. Today there are more math departments that have large cohorts of women students, and a few even have a relatively large number of women faculty. But many departments have not gotten there yet, and many women math majors or math graduate students still find themselves in a minority or even as the only woman in some of their classes. “It’s very isolating,” McDuff says. “Having role models and having a concentrated group of women working together—people find it transforming.”

Uhlenbeck offers, “Women don’t do different math than men.” But male-dominated environments can make it more difficult for women to participate fully. The supportive atmosphere of WAM and the participation of women in many different career stages can make younger students feel less vulnerable as they wade into research mathematics. “For many people who attend, they have not met so many female mathematicians at once,” University of Kentucky mathematician and WAM Academic Program Manager Margaret Readdy says. Seeing so many successful women ahead of them can help them see a path forward.

“There is something different about a room full of women,” University of Michigan mathematician Anna Gilbert says. She participated in WAM in one of the first years of its existence and has returned since as a lecturer. “I think it’s palpable to everybody.” She says programs like WAM can be especially valuable when they help students build their confidence and comfort talking about mathematics to a variety of people. “It’s nice to spend a while talking about exciting research and feeling comfortable doing it,” she says. “If meetings like this can facilitate that, they’re important. It’s also important to get to the point where you feel comfortable talking excitedly about your research no matter the setting.”

Doing the Math

The core of WAM has always been the math content courses. There are two lecture courses each summer. They used to be referred to as the beginning and the advanced courses, but they were recently renamed for WAM founders Terng and Uhlenbeck. In the early years, it was especially important to the organizers that the program be seen as a rigorous mathematical experience so it could gain credibility. Uhlenbeck remembers a student whose (male) advisor was skeptical



WAM participants study on the IAS campus.

“As a mathematical community, we should always think, ‘Are there new ways in which we could structure ourselves?’”
—Robbert Dijkgraaf

about the need for women-only math programs. “My thesis advisor did not believe in this,” she recalled the student saying, “but, he said, ‘it’s a program run by Karen Uhlenbeck and the mathematics is good, so you should go.’”

The program themes are tied to the yearly themes of the IAS seminar School of Mathematics and have covered applied topics such as mathematical biology and cryptography to theoretical mathematics fields like geometric group theory and the Langlands program. For many of the undergraduates, this is their first exposure to research-level

mathematics.

After lectures, daily TA-led problem sessions get students working together to digest the mathematics from their courses. “It’s much more hands-on and significantly more challenging than TA-ing any other course I’ve done,” says freelance math and science writer Yen Duong, who was a TA during the 2017 program. “It’s more similar to a postdoc or professor’s work of doing a topics class in more current research.” The atmosphere was different for her as a TA than it had been when she was participating as a grad student, but, “I was still able to have those deep, insightful conversations that come about when you throw these women together who have had similar experiences,” she says.

Advanced graduate students and postdoctoral participants organize a Women in Science Seminar in the afternoons. The seminar enables students to give talks about their work, often for the first time outside of their home institutions. “When I think of when I first started to give talks—they were awful!” says Readdy. Learning to give a good talk is a humbling, slow process. WAM organizers are trying to make the process easier and more enriching for students. Not only do advanced students and postdocs give these talks in the supportive WAM environment, but they also receive constructive feedback afterward. Readdy makes sure some senior women are in the audience at each talk, usually herself and other women in the speaker’s field. She asks them to share specific comments about what worked for each talk and where speakers have room for growth.

For anyone who has finished a talk feeling like they needed to read tea leaves to tell whether their audience was engaged and following them, the prospect of honest, kind feedback from mathematicians who really know what they are talking about is tantalizing. “That’s something you never get” at other conferences, Readdy says. She is working on putting together guidelines for new speakers that she hopes will help raise the caliber of their first talks and allow them to mature even more quickly.

Becoming Mathematical Citizens

In addition to course lectures, problem sessions, and research talks, WAM programming includes other educational, social, and outreach opportunities. The programming depends largely on the interests of the participants and changes from year to year. In the early years, the Women in Science Seminar was organized by Uhlenbeck and had a diverse set of offerings on topics outside of the course content. She would invite science historians to share histories and biographies of women in math and organize discussions of issues facing women mathematicians.

Participants can organize evening programs about many hot-button issues. Questions of equity and justice in mathematics classrooms and in research spaces are of increasing interest to young participants, who initiate discussions about these topics. For example, as the broader society's understanding of gender identity has evolved more toward seeing it as a spectrum (or even a higher-dimensional mathematical object) rather than a binary variable, some participants have organized discussions on the topic of gender in mathematics. Being willing to tackle these topics with provocative speakers "incites more, and better, and deeper conversations and questions," Duong says. "The undergraduate and beginning graduate students almost feel like kindling, and they're catching the flame for more justice in the mathematics world. That gives me great hope."

Interested participants also have the opportunity to perform local outreach while they attend WAM. Aside from visits to local schools, participants have attended local 5K races and set up tables demonstrating fun extracurricular math like a non-transitive dice game and Eugenia Cheng's method for cutting a bagel into two linked halves.

Participants are housed together, either on campus in Institute-owned apartments or at a hotel in downtown Princeton. They walk to classes together, share meals on campus, and socialize in the evenings. "For this group of female mathematicians from various backgrounds and various stages of their scientific career, spending time together is very important," Dijkgraaf says. "It creates bonds that last a lifetime."

Focus on Careers

Career and work-life balance panels are common programming at WAM. Although many graduate students still see it as the one true career path, becoming a research mathematician is an alternate career in the sense that most people who enter graduate school to study mathematics will not eventually have tenure at a university. WAM—like many organizations that serve mathematics students—is increasingly focusing on giving career advice and guidance that acknowledges that particular reality of mathematical careers.

"As a community, I personally feel we could spend more time on thinking about what it means to be a mathemati-

cian," Dijkgraaf says. What does it mean to have a career in math? What sacrifices are involved in the academic career path, or industry, or government? How will a mathematical career align with your broader values? "This is something quite general," he says. He feels that as a student, these questions were often neglected in favor of a more myopic focus on courses and content. "Spending a week or two together and having the opportunity to have these exchanges might be as valuable as the math you learn and the contacts you make," he says.

Organizers have found that students are more and more interested in hearing from nonacademic career panelists. They want to know about the range of options available and how to prepare for both applying to and working in nonacademic jobs. "One of the values is that younger women come here and get to see such a broad variety of older women around them," Uhlenbeck says. "I'd hate to think that everybody with a PhD has to become a research mathematician." They can see role models who have a variety of mathematical careers and get a better understanding of the skills and background that would be most helpful for each one.



Robbert Dijkgraaf, director of IAS, talks with WAM participants.

One recent addition to WAM that is useful for both academic and nonacademic careers is a focus on computer skills. "We feel strongly that every young mathematician these days should know how to do something with computers," McDuff says. For example, during the 2018 WAM program, which had a theme of modern cryptography, participants learned to use Sage and LMFDB, an online database of L -functions, modular forms, and related objects.

In recent years, New Jersey-based manufacturer Johnson & Johnson has hired one WAM undergraduate or beginning graduate student as a summer intern, starting after the end of WAM that summer. The intern works in several different roles in the company and learns about the ways math modeling can be used in pharmaceuticals and medical devices as well as business marketing and sales. Johnson & Johnson has been consistently impressed with the quality

of interns they have gotten, and students have enjoyed the hands-on experience. “It is a symbiotic relationship where both parties—the intern and the company—are happy,” Readdy says.

Impact

In its 25 years, many prominent and successful women in mathematics have participated in the WAM program. About a third of the recipients of the Alice T. Schafer Mathematics Prize for excellence in mathematics by an undergraduate women have participated in the program, along with about a sixth of women recipients of NSF graduate fellowships, and a third of women recipients of NSF and Sloan postdoctoral fellowships. A sixth of women ICM invited speakers and more than half of women ICM plenary speakers have gone through the program. To be clear, correlation is not causation. Women with strong interests and backgrounds in math are more likely to be interested in and participate in WAM and all of the aforementioned programs. But many alumnae of the program who continue to progress in mathematics research careers cite the rigorous, collegial atmosphere as a place of growth and encouragement.

One of the most ringing endorsements of the program is the fact that so many people involved come back. “We have many participants who return in various forms,” Huguenin says. Women who participate as undergraduates often come back as graduate students or postdocs; former participants return as lecturers; some alumnae end up returning as members of the IAS, spending one or two years working on their research at the Institute.

After participating in WAM as a graduate student in 2016, Duong knew she wanted to be involved in the future. “I brought it up before I even left,” she says. She asked the organizers whether there was a way she could come back to the program. By a lucky coincidence, the next year’s mathematical theme was also related to her research, so she came back as a TA.

Professional collaborations begin at WAM as well. “I’ve talked with people who say they’ve changed their research area as a result of attending WAM,” Readdy says. Spending so much time talking with other young women who are interested in the same area of math can ignite interest in proving theorems together. Huguenin recalls a pair that started working together at WAM several years ago and recently went back to the Institute as part of the Summer Collaborators program.

One of the criteria for the Mathematics Programs that Make a Difference Award is that the program has a replicable model. While the tranquil setting of the IAS and its history and prestige in the mathematics community are unique, women-only programs that focus on current mathematics research have proliferated in the decades since WAM was established. WAM has shown the value of bringing women at many different stages of their career

together for intensive workshops and conferences. Today, women mathematicians can find a host of conferences and informal networks of others in their specific research fields: Women in Numbers, Women in Topology, Women in Probability, Women in Mathematical Biology, Women in Sage. The list goes on. MSRI semester programs begin with short Connections for Women conferences to help build a community of women who will be participating either in the weeklong conferences or the full semester. The EDGE (Enhancing Diversity in Graduate Education) program has helped women from underrepresented racial and ethnic groups and first-generation college students start graduate school on the right foot. The WAM Ambassador Program

WAM Ambassadors

Two years ago through a donation from Lisa Simonyi, the WAM Ambassador Program began. Through small grants, this initiative allows participants in the summer program at IAS to take their ideas to the broader community. Each year, up to six graduate student alumnae will receive funding to help support undergraduate math majors at their universities, and up to three postdoctoral or advanced graduate student alumnae receive grants to fund small conferences or outreach programs. “We want them to take their experience from here, bring it home and put it to use in whatever way works best for them,” Huguenin says.

In 2017, the first year of the program, Yen Duong organized the Carolinas Women in Mathematics Symposium at the University of North Carolina at Charlotte. Similar conferences took place at several other schools, including Carnegie Mellon University and the University of Wisconsin. Undergraduate grants have funded Association for Women in Mathematics student chapter activities, reading groups about both mathematics and gender equity, and outreach activities geared toward children in the community. This coming year, one undergraduate grant will be used to fund a Wikipedia edit-a-thon where students will research women mathematicians and add or expand on biographies of women in math on Wikipedia.

The year after the program is funded, each Ambassador comes back for the summer program to discuss their grant-funded award and its outcome. “I think the point is to harness the creativity of these young women in mathematics,” Duong says. She recalls talking with other WAM participants about how nice it would be to be able to take some of the energy and camaraderie from the summer program to institutions around the country. “It took off from there,” she says. “They have the ideas from the program, and then with the grants they have the tools and resources to actually carry those ideas into fruition.”

has helped create small regional conferences and other activities to support the work of women mathematicians around the country (see sidebar).

“One lesson that I have learned [from WAM] is that we should be experimental in always thinking of new ways to bring mathematicians together,” Dijkgraaf says. He hopes WAM will also provide a model for people looking to increase participation by members of other groups that are underrepresented in mathematics. “As a mathematical community, we should always think, ‘Are there new ways in which we could structure ourselves?’ particularly, I think, if our aim is to make math the most inclusive subject,” he says. “Math has always benefited from having new points of view.”

Increasing Access

WAM has, on average, 150 applicants each year, but the size of the venues and the desire to keep the atmosphere intimate keeps the cap on attendees around 60. Organizers are continuously assessing their recruitment and admission procedures to try to encourage diversity along many axes.

In 2016 the program established childcare grants to make it more accessible to participants with children. Moms, dads, and nonbinary parents all have childcare responsibilities, but these responsibilities tend to fall disproportionately on women, especially when children are very young, and the cost of childcare can be a barrier to women’s participation in conferences and other professional activities. Duong was able to come back to WAM as a TA because of a childcare grant that allowed her to bring her mother to care for her infant daughter. Shortly after implementing the childcare grant program at WAM, the IAS expanded the scope and now offers childcare grants to participants at all of their programs.

Other recent efforts at broadening access have focused on the types of schools participants attend. Many R1 universities have strong ties to the IAS, and as a result their students have had easier access to a broader range of upper-level math courses and programs like WAM. “The goal of the program is broader than just encouraging the women who already have everything going for them when they arrive at the point of applying to graduate school,” Uhlenbeck says. To help draw in students from other backgrounds, the WAM committee actively recruits students from historically black colleges and universities and from smaller and less research-oriented universities. About a third of the undergraduate participants have been members of racial or ethnic groups that are underrepresented in mathematics and about half have been students at universities that do not confer doctorates in mathematics.

WAM is flexible. Organizers and participants are adapting the program to changes in math department offerings and the job market. The organizers are optimistic about its continued relevance and influence in the broader mathe-

matical community. Uhlenbeck says, “The program is in good hands and...thriving.”



Evelyn Lamb

Credits

All WAM program photos are by Andrea Kane, courtesy of IAS.

Photo of Evelyn Lamb is by Jon Chaika.

EDITOR’S NOTE. See the official 2019 AMS Programs that Make a Difference Award announcement and citation, page 742.