Finding and Keeping Graduate Students in the Mathematical Sciences

organized by
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Workshop Summary

The Problem

Despite the fact that the American system of graduate education in mathematics attracts talent from around the world, there are reasons to be concerned about its ability to both attract U.S. citizens and permanent residents and to avoid attrition by able students. Recently, less than half of graduating doctoral students in the mathematical sciences have been American.[1] Females account for only 30% of the American cohort; African-American, Hispanic-American, and Native American students *together* make up barely 7% of this cohort.

> Increasing participation of underrepresented[2] minorities is critical to ensuring a high quality supply of scientists and engineers in the United States, over the long term. As minority groups increase as a percentage of the US population, increasing their participation rate in science and engineering is critical if we are just to maintain the overall participation rate in science and engineering among the US population. Perhaps even more important, if some groups are underrepresented in science and engineering in our society, we are not attracting as many of the most talented people to an important segment of our knowledge economy.[3] (National Academy of Sciences, 2006, p.7-5)

A healthy mathematics community is essential for the United States to meet the demand for technological and quantitative development. Companies holding federal contracts are in many cases limited to hiring U.S. citizens or permanent residents for jobs requiring advanced mathematical education. In some cases they are limited to hiring citizens only. These agencies have a need to ensure strong participation in mathematics by all American students. If American institutions are not visibly sympathetic to this concern, there may be a reluctance to maintain or increase federal support for academic mathematics. The populations that currently tend to be well-represented in graduate programs in the United Statesprimarily white mencannot meet the upcoming demand for mathematical scientists, as their proportion of the overall population declines. Further, systems that fail to diversify are often unstable and vulnerable; the strategy of using diversity to ensure long-term vitality has served well in a variety of natural, social, and economic systems. Increasing the diversity

[1] Kirkman, Ellen E., Maxwell, James W., and Rose, Colleen (2006). 2005 Annual Survey of the Mathematical Sciences (First Report). Notices of the AMS, 53(2), pp 230-245.

[2] In the case of doctoral level mathematics, we consider underrepresented minority groups to include African American, Latino/a, and Native American U.S. Citizens and permanent residents.

[3] National Academy of Sciences, Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Pre-publication version, February 2006. Washington, DC: The National Academies Press.

of those who participate in mathematicscan help the profession flexibly meet the challenges posed by the growing quantitative sophistication of economic and political structures in the 21st century. Finally, mathematics serves as an important gateway to many careers and disciplines of study; ensuring that all students have the opportunity to succeed in mathematics is important to a democratic vision of education. For all of these reasons, it is clear that people of groups traditionally underrepresented in mathematics represent an untapped and much-needed resource for growth of the mathematics profession.

The Workshop

The workshop *Finding and Keeping Graduate Students in the Mathematical Sciences* was held at the American Institute of Mathematics Research Conference Center on December 4-8, 2006. The primary goal of the workshop was to build on recent efforts by organizations, institutions, and individuals within the mathematics community to enhance the recruitment and retention of graduate students in the mathematical sciences, with a particular emphasis on U.S. citizens and permanent residents, women, and students from underrepresented groups.

We brought together leaders in graduate education in the mathematical sciences from eight graduate programs, giving them the stimulus to take their efforts to improve the recruitment and retention of diverse graduate students to the next level. Eight teams of 2 or 3 members each represented George Washington University,North Carolina State University, the Ohio State University, Rutgers University, the University of Arizona, the University of California-Berkeley, the Universityof California-San Diego, and the University of North Texas. Most of these teams included either a representative of the graduate dean, or a department officer such as a chair or graduate director. These teams learned from the experience of individuals with a record of success in recruitment and retention (Lenore Blum,Carnegie Mellon University; Sylvia Bozeman, Spelman College; Carlos Castillo-Chavez, Arizona State University; David Manderscheid, University of Iowa; John Meakin, University of Nebraska-Lincoln; Richard Tapia, Rice University). Other presenters included Amy Cohen-Corwin (Rutgers University), Abbe Herzig (University atAlbany), Cynthia Johnson (Rice University), and Maria-Teresa-Velez (University of Arizona). Through a series of panel presentations, in-depth discussions, and structured planning activities, the 28 individuals participating in the workshop shared a varied mix of principles and specific, detailed examples of initiativesthat have been successful in recruiting and retaining graduate students in general, and students of underrepresented groups in particular, in the mathematical sciences.

The workshop was organized around three general themes:

- Recruiting and admissions,
- Supporting students as learners and as people, and
- Mentoring the development of professional mathematicians.

Outcomes

Each of the eight participating campus teams had already been working to improve the quality of their graduate programs, in most cases with a focus on improved recruiting and retention of students of underrepresented groups. Participants worked throughout the week to formulate concrete, written plans to build on these efforts. Each team constructed plans that were designed for their particular institutional contexts. Each team identified:

- Strengths and weaknesses in the graduate program and department,

- Overall goals for long-term change, and
- Specific programs or initiatives they will work to expand or implement.

Several persistent themes were identified by the facilitators and participants:

- The importance of *mentoring* (as distinct from advising) and other meaningful, supportive relationships between students and faculty, including the mentoring of faculty who play important roles in the graduate program.
- *Building community* among graduate students and between students and faculty, as a way of helping students become integrated into the department and program, thus enhancing their learning and their progress.
- Involving graduate students in *authentic mathematical activities*.

A broad range of ideas was generated and discussed with facilitators and organizers. The lists below include examples of initiatives designed by the teams, grouped according to the three general themes of the workshop. Of course, there is overlap, and items listed in one category often contribute to other goals as well. We emphasize that no one department will attempt to implement all of these ideas at once. *Each of these initiatives has had proven success at one or more U.S. mathematics department(s)*, and the campus teams discussed how to adapt them for their own institutional contexts. There was substantial discussion about sources of funding these initiatives, and a number of plans for seeking funds was generated. More details about the plans constructed by each team can be found on the password-protected website constructed and supported by AIM as part of AIMs follow-up support for workshop participants.

Recruiting and Admissions

Our discussion of recruiting and admissions included recruiting applicants to apply, admissions practices and criteria, and recruiting admitted students to enroll. Plans of the campus teams include:

1.1. Exploit existing networks (e.g. networks of state colleges or other organizations) and develop new networks with targeted schools (in particular, HBCUs and Hispanic-serving institutions) for recruiting talented undergraduates into graduate study.

1.2. Develop internal and external resources to increase stipends for offers to new students.

1.3. Develop a holistic approach to identify talented and motivated students in reviewing applications. Re-think reliance on the GRE and other measures in the admissions process. Distinguish between prior performance and opportunity and future promise.

1.4. Involve graduate alumni, current graduate students, and faculty as recruiting ambassadors with undergraduate schools and high schools.

1.5. Implement a recruiting weekend to help admitted students learn about the graduate program, through classroom visits, panel discussions with current students, and community-building activities.

1.6. Improve the web presentation of the department or graduate program, including profiles of students and alumni to communicate the range of people that participate in mathematics and the range of mathematics they do.

1.7. Make it clear on the website and in other marketing materials that diversity is valued.

1.8. Establish a faculty-led Diversity Committee.

1.9. Keep all of these goals in mind when selecting members of faculty admissions committees.

Supporting Students as Learners and as People

Our work on supporting students as learners and as people was informed by a model of apprenticeship from the social sciences.[4] This model emphasizes the importance of *authentic activities* and *interactions with masters* for the training of apprentices, and identifies three dimensions of learning that are important. We translated those three dimensions into the training of

graduate students as helping students learn and create *mathematical content*, helping students learn the practices of mathematics, and helping students develop *identities as members of a mathematical community*. Teams used these three dimensions of learning to guide their planning.

2.1. Provide structured peer and faculty mentoring to all students. Hire advanced graduate students as mentors for new graduate students, including new recruits and incoming students prior to entry.

2.2. Hire advanced graduate students, or use other means, to help students prepare for preliminary or qualifying examinations.

2.3. Modify examination and other program requirements to correspond more closely to educational objectives, or replace qualifying exams with well-documented coursework.

2.4. Bring alumni or other speakers, particularly women and people of color, to give talks and to interact with current students. Invite colloquium speakers who can give talks that are accessible to all graduate students.

2.5. Send students to conferences and help them prepare in advance. Encourage and support students to present research results.

2.6. Allow students more time and support to master the basics, as appropriate. Allow time and advising for undergraduate courses when necessary. Implement a summer program to bring students up to speed for graduate work, and provide support for participating students.

2.7. Provide graduate students with early research experiences, with faculty as mentors. Offer a research seminar for incoming students to learn about research from faculty and advanced graduate students.

2.8. Provide students with increased opportunities to get involved in the work of the department and mathematics community more broadly.

2.9. Organize problem sessions for first-year graduate courses, led by faculty or advanced graduate students.

2.10. Select instructors of first year courses carefully, and discuss expectations.

2.11. Sponsor social events to encourage students and faculty to interact as people.

2.12. Create a Faculty-Student Advisory Board.

Mentoring the Development of Professional Mathematicians

In our third focus, we discussed the nature of mentoring of graduate students, of new faculty, and of faculty who take on special roles (e.g. graduate program directors or instructors of first-year courses). For graduate students, we talked about two important aspects of mentoring: mentoring students through the program, and mentoring students for career development.

[4]Lave, Jean & Wenger, Etienne (1991). Situated Learning: Legitimate Peripheral Participation. Cambridge, England: Cambridge University Press.

3.1. Interact more closely with students to take the temperature of student morale, and learn more about students experiences in the program. Find out when mentoring fails and why.

3.2. Help faculty explore the meaning of mentoring. Encourage formal and informal conversations among faculty about the role of a mentor, and how it differs from that of an advisor. Train advisors and mentors, and discuss expectations and strategies.

3.3. Build an infrastructure for mentoring. Develop a principled (rather than random) way to match students with mentors.

3.4. Centralize the monitoring of students progress through the program, so that mentoring and support can be made available when necessary.

3.5. Create an Advising Committee for first year students.

3.6. Select faculty carefully to be advisors and coaches for incoming graduate students.

3.7. Prepare graduates to maintain a level of intellectual activity should they go to a 4-year institution, by bringing back alumni speakers who have done this.

3.8. Provide mentoring and training for teaching. Involve students in teaching advanced undergraduate courses.

3.9. Provide internships for students to learn about working in industry.

3.10. Provide a career seminar or lecture series with speakers from various academic environments and industry.

3.11. Create a seminar series in which students can learn professional skills: practice job talks and get feedback from faculty; explore grant-writing; select journals for publications; learn the nuts-and-bolts of applying for jobs, including the range of job opportunities available to mathematicians.

Other general ideas

4.1. Revise the reward system for faculty to encourage more faculty involvement in these efforts.

4.2. Make changes in faculty hiring in order to get a mix of faculty that are more diverse in research interests and who are more interested in meaningful interaction with graduate students.

4.3. Mentor new faculty in the importance of mentoring graduate students.

4.4. Develop physical space that is conducive to social and professional interactions.

Next Steps

This workshop was a critical step in providing the campus teams the time and stimulus to construct plans to improve their work to find and keep graduate studentsin their graduate programs. These initial plans were one of the primary goals of the workshop.

In addition, the energy and focus developed within the workshop provides an opportunity for stimulating much more profound and widespread change in graduate student recruiting and retention, particularly for women and underrepresented minorities. Our goals for the workshop also included (1) supporting the ongoing work of the campus teams as they further develop and implement their plans, and (2) disseminating successful strategies to a broad audience of mathematical scientists.In order to meet these additional goals, the group developed the following plans. As a group, we will explore opportunities to implement these (and other related) programs.

- Through ongoing communication among the presenters and participants following the Workshop, we will provide support as necessary to help the campus teams further

develop their plans, will monitor and document their progress, and provide feedback as they implement their plans.

- A reunion meeting of this group should be held in late 2007 or 2008, to follow up on team efforts, provide ongoing stimulus for further work, allow teams to share ideas and cooperate on solving problems, and to support one anothers efforts.
- The American Institute of Mathematics will support a website for conference participants to communicate about ongoing work, including posting team plans and progress and other relevant materials. We will also use a listserv for ongoing communication.
- This workshop will be offered annually, with new campus teams attending each year. The work of the participants from earlier workshops will become resources for other interested campuses who want to develop their own programs to enhance the recruiting and retention of graduate students. Our hope is to use a series of established successes, described by the various presenters, as resources for fledgling recruitment and retention efforts, and then to document these efforts as they each mature, using them as additional models for future efforts. Year after year, new campus teams will be brought into the community developed through this workshop, creating a growing network of mathematical scientists working on behalf of improving graduate educational opportunities for students of underrepresented groups.
- A conference will be held in 2008 to bring together representatives from minority-serving colleges and from institutions with graduate programs. As these faculty learn about each others programs, they will build specific channels to encourage undergraduate mathematics majors to continue into graduate study, in graduate programs where they will be well-supported and are likely to have positive experiences.
- Workshop facilitators and selected participants will form a professional network of consultants and speakers to conduct on-site training for departments that want to develop their graduate programs to be more supportive of diverse graduate students.