

Women Mathematicians in the Academic Ranks: A Call to Action

Report of the BIRS Workshop* on Women in Mathematics
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Table of Contents

A Call to Action: Rationale, Goals, and Recommendations	Page 1
§1. Recruitment, Hiring, Retention and Promotion	Page 4
§2. Environment and Climate	Page 8
§3. Family and Personal/Professional Life Balance	Page 12
§4. Professional Development and Leadership	Page 14
Conclusions	Page 16
Authorship	Page 17
References	Page 18

A Call to Action: Rationale, Goals, and Recommendations

The vitality of the scientific enterprise and the prosperity of the North American countries depend on the broad development of the mathematical sciences and on full access to that development by all members of society. Against this noble and sweeping statement, we observe that the proportion of women in academic mathematical sciences declines at each successive professional level, beginning with Ph.D. graduates and progressing through senior faculty and administrators. Women in mathematical sciences continue to experience a broad range of obstacles to their professional development, career growth, and job satisfaction. The authors of this report convened at the Banff International Research Station for Mathematical Innovation and Discovery (BIRS) on September 24–28, 2006, to develop a call for action to improve the representation and experiences of women in mathematics in North America.

Our goals were:

- To review existing research and data concerning the situation for women in mathematics in Canada, Mexico, and the United States.
- To identify policies and practices that have been successfully implemented by mathematics departments, universities, professional societies, and research institutes. We call these *Good Management Practices*.

* http://www.birs.ca/birspages.php?task=listpars&event_id=06w5504.

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- To develop recommendations based on these successful strategies, and to identify areas that require further attention.
- To encourage action by professional societies, including the American Mathematical Society, Canadian Mathematical Society, Mexican Mathematical Society, Mathematical Association of America, Society for Industrial and Applied Mathematics, Canadian Applied and Industrial Mathematics Society, Institute of Mathematical Statistics, American Statistical Association, and Association for Women in Mathematics.
- To encourage action by mathematics institutes, funding bodies, university administrations, mathematics departments, and department chairs.
- To disseminate our findings to mathematicians and statisticians, administrators and policymakers in mathematical sciences, to be used both as a resource and as a *Call to Action* to work in tangible and measurable ways to improve the situation for women in mathematical sciences.

We draw on a range of earlier reports [1] on the status of women in a range of scientific disciplines. We interpret the findings of these reports and of other research in the light of the culture of the mathematical community. Relying on the expertise of an established group of mathematical scientists, we distill those features that are most relevant to the unique disciplinary and professional characteristics of the mathematical sciences. In this report, we present specific recommendations for action.

Rationale. *The vitality of science and the prosperity of society depend on the broad development of the mathematical sciences and on the full participation of all members of society.* Among the reasons that action is needed is the widely-recognized demand for an increase in mathematical capacity, in all countries and at all levels. There is a need for mathematicians, for teachers of mathematics, and for researchers and practicing scientists who are knowledgeable about and comfortable with mathematical tools. In North America, some of the growth can be achieved only by including women and minorities in greater proportions than today. Many women begin in mathematics eager and able to contribute, as do many members of other underrepresented groups. However, current structures of dubious efficacy, often in place by force of a conservative tradition, inhibit their participation. Moreover, there is evidence that unexamined assumptions and unconscious bias persist as a significant hindrance to women and others. There is also evidence that changes in structures and practices can make a difference, and hence that appropriate efforts are necessary and will be effective.

Goals. According to the authors of this report, an important goal of the mathematical sciences community is to increase the presence of women in mathematics at all levels. We have focused on our own community – academic mathematical sciences – and our recommendations are aimed at increasing the success rate of women Ph.D. students, increasing the number of women who enter the postdoctoral fellow pool, increasing the ratio of women getting tenure-track faculty appointments, increasing the ratio of women getting promotions and tenure, increasing the ratio of women moving to leadership

positions, increasing women's satisfaction with their careers, and increasing the level of recognition and reward for women in the mathematical sciences.

Recommendations. Flexibility is essential in all quarters. This cannot be overstated; a recurrent theme at our workshop and in the reports states that adherence to a rigid model of a mathematician's career path is a powerful deterrent to success for non-traditional entrants to our community. At the workshop, participants identified the need for change in four general areas:

1. hiring, retention, promotion and data collection
 - recruitment: broaden search criteria and widen outreach.
 - hiring: identify and use multiple dimensions in evaluating applicants.
 - retention and promotion: make decisions based on true academic age, and encourage tenure-clock flexibility.
 - records: collect data and monitor success rates at all levels.
2. workplace environment and climate
 - view students and recent Ph.D.s as apprentice mathematicians.
 - mentor: seek points of contact between senior expertise and junior needs.
 - make expectations clear: just as in teaching mathematics, the obvious needs to be stated.
 - remove obstacles: rigid applications of outdated practices are harmful to the individual and to the institution.
3. attention to career/life balance by universities
 - measure true academic age only, with tenure-clock adjustments for leaves.
 - offer part-time options.
 - provide on-site and affordable childcare.
 - establish supportive childcare and family leave policies.
 - be sensitive to the desire for work/life balance on the part of all members of the workforce.
4. professional development
 - provide scientific opportunities for re-entry in research after an interruption.
 - ensure transparency in access to opportunities.
 - maintain an open attitude toward non-traditional but valuable mathematical activities.

In the four sections of this report we will take up each of these four areas in turn, providing succinct and specific recommendations for action.

Good management practices have been described in many of the reports we have referenced. However, as far as we can determine, no detailed study exists that considers the specific discipline of mathematics. Mathematics has a distinct culture, and the issue of systemic barriers in the advancement of women in mathematics is difficult and subtle. Anecdotal evidence suggests that mathematicians as a group will dismiss any study concerning hidden bias that is not specific to mathematicians and mathematical sciences departments. Thus it is important to acquire systematically collected data in order to target changes, and to obtain widespread acceptance of any proposed changes.

- We call for the design and funding of a broad scale, multi-year study of hiring, promotion and retention data across representative mathematics departments in each of the North American countries.

§1. Recruitment, Hiring, Retention, and Promotion

Women are at a disadvantage in the hiring and retention processes that are commonly employed by mathematics, science and engineering departments across North America [2].

Although about 30% of Ph.D. degrees in mathematics go to women, only 6% of the faculty positions in mathematics in the top-tier doctoral-granting universities in the United States are held by women. Of particular concern is the fact that this figure has not increased over time, even though the proportion of women earning doctoral degrees has increased [3].

We call for mathematics departments in North America to examine, articulate, and rethink their hiring and retention practices. Several recent studies [4] lead us to recommend the following concrete points of action:

- **Recruitment:** *Broaden search criteria and outreach.* Identify, independent of search parameters and early in the process, women mathematicians of promise. Expand the recruitment process across multiple semesters, through invited seminar and colloquia talks, conference invitations, visiting positions, and other forms of informal recruiting.
- **Hiring:** *Use multiple dimensions in evaluating applicants.* In particular, consider the many criteria which go into determining the contributions of faculty to a department throughout their careers. Be aware of and correct for evaluation biases (for example, reliance on stereotyped images of success). Consider *breadth, depth, visibility, interdisciplinary strengths, entrepreneurship, teaching, and outreach.*
- **Retention and Promotion:** *Tenure clock flexibility is essential.* Develop policies that allow young faculty to meld their professional and family responsibilities successfully. Provide resources to enable young faculty to

enhance their networking capabilities, and provide comprehensive mentoring by senior faculty leaders. Expand criteria used for promotion to consider the expected contribution over the whole of the candidate's career. Clearly communicate the evaluation practices and criteria that will be used by the university in evaluation of faculty.

- **Data Acquisition:** We call on departments and institutes to *collect, quantify, and track data* concerning recruitment, hiring, retention and promotion processes over the years. Without data it is easy to deny the problems, and difficult to know how one is doing and where the difficulties may lie.

Discussion. We believe that two goals for mathematics departments are (1) to have the proportion of women on the faculty track reflect the proportion of women receiving Ph.D.'s in mathematics, and (2) to have women in leadership positions in proportion to their presence in the department. Substantial evidence [5] exists to indicate that current standard practices fall short of these goals.

Our group recommends concrete steps in each of the four categories above.

Recruitment

A common barrier to excellence and diversity in an applicant pool is the presence of a narrowly defined search process. Too often, excellence and diversity are viewed as competing, rather than as the complementary and reinforcing goals which they should be. Steps which will enhance the recruitment process should become standard.

- Ensure flexibility in every aspect in the design of the search. The department and university should be flexible in terms of rank, field of focus, and number of positions in a given year, even if it results in temporary inconvenience. In particular, candidates who have time remaining in mentored postdoctoral positions must be given the opportunity to complete their fellowships prior to assuming faculty duties.
- Identify potential female candidates early, and familiarize your faculty with these candidates through invitations to speak in seminars and colloquia well in advance of a search. Establish a Long-Term Recruitment Committee. Send representatives of this committee to the departments from which the institution regularly recruits, to institutes and to national meetings.
- Ensure that the hiring committee reflects the diversity of the faculty that a department hopes to hire. If necessary, involve colleagues from other departments or institutions to achieve this diversity.
- Announce and emphasize the institution's commitment to inclusion of women and minorities, for example by establishing a position such as a Dean of Diversity for Science. This position must be filled by a person of strong professional and

personal reputation within the institution, and s/he must be an active and empowered participant in all recruiting and hiring activities.

- Enlist female and junior faculty members' participation in the design and implementation of the recruiting process. Recruit via women's professional networks, such as the Association for Women in Mathematics, and through personal contacts. Advertise broadly and with appropriately worded advertisements. Contact potential candidates and their mentors and ask them to apply.

We alert departments to be especially aware of common mistakes that impede the recruitment of women. In particular, the strategy of producing a short list of candidates via a linear ordering obtained by rigid criteria is especially deleterious to increasing diversity. One possibility is to consider constructing multiple short lists according to varied criteria. Mathematicians are perhaps better able to rank candidates than are our colleagues in other disciplines, and mathematicians are perhaps better able to assess a candidate's qualities at an early career stage. However, both of these abilities can work against hiring a diverse faculty, especially if not tempered by a strong understanding of the variety of forms taken by talent and promise [6].

Hiring

Examples of hiring practices which result in a more inclusive process have been described in many of the reports referenced earlier [7]. It has been recognized that most of the practices and expectations of academe were developed at a time when faculty members were male, either single or with home-based wives. This has resulted in a particular culture which persists in defiance of today's realities and which fosters selection from a small homogenous group. In the hiring process, those who fit this mold are more likely to be judged on their promise, while those who do not are judged on their accomplishments [2].

To achieve the goal of hiring a diverse and outstanding faculty, we recommend the following practices. Because of the fluid boundary between recruitment and hiring there is naturally some overlap with our recommendations under "recruitment."

- Have an explicit policy of flexibility in hiring with regard to rank and field. Consider dual hires, and attempt to facilitate transitions via temporary spousal appointment tracks within the hiring institution. Have the flexibility to make aggressive offers to outstanding candidates early in the hiring season.
- Omit language (including gendered pronouns) in the job advertisement that may inadvertently discourage women from applying. Advertise in a variety of venues including Association for Women in Mathematics sites [8].

- Create a search committee that is representative of the diversity of the faculty you are hoping to hire. Staff the search committee with mathematically diverse and accomplished faculty, in order to ensure that a broad view of the target field is achieved.
- Provide all candidates with information packets containing institutional information, especially concerning dual career and gender initiatives, as well as family policy programs.
- Use multiple criteria for evaluating applicants, avoiding a one-dimensional process. Evaluate all candidates in the hiring process using the same criteria. Be aware that the most vocal members of the committee and department may have the most influence. Actively solicit input from other voices in your department. Make clear to the whole of the department what the hiring process and criteria are, and facilitate channels for communication and input from the faculty to the hiring committee. View “résumé gaps” and other non-traditional aspects of a candidate’s curriculum vitae with an open mind.
- Bring the presence of evaluation biases to the attention of your department and the members of the search committee; as an example, see Chapter 4 in [2]. Develop strategies for countering these, such as starting the hiring season with a presentation on bias, preferably by a trained outsider with expertise on this topic.

Retention and Promotion

It needs to be acknowledged that society often places significant familial responsibility on women during their probationary period in tenure-track positions. These responsibilities do not have to be an impediment to a long and successful academic career, but without intervention they can become a major stumbling block. Indeed, faculty members who are able to achieve a healthy balance between their personal and professional responsibilities are most likely to sustain a high level of contribution throughout their careers. Policies which are sensitive to special circumstances result in benefits to all faculty members as well as to the institution. This is not always well understood.

Retention Strategies. With a focus on the retention of faculty through the pre-tenure stage of their careers we make the following recommendations.

- In light of familial responsibilities, tenure clock flexibility is essential. The assessment culture must also be changed, in order to view without negative connotations a lengthened tenure clock.
- The institution should supply high quality and flexible on-campus child care. On campuses where there are faculty unions, these organizations could play a

decisive role. On any campus, strong leadership on this matter must come from some source.

- Family policy practices and benefits should be widely publicized to the faculty, department chairs, and relevant administrators, and advertised as beneficial to the health of the institution (which they are). Institutional vigilance is required to insure that users of these benefits are not penalized.
- Provide resources at critical career junctures (for example, midway through the pre-tenure period) via sabbaticals, research resources, travel allowances, and grant writing or other support.

Promotion Strategies. We now focus on the process of evaluating the candidate at the time of tenure. We make the following suggestions.

- It is important that candidates reach the promotion stage in possession of a clear understanding of the evaluation criteria as it applies to their cases. It is important that all candidates be assessed using a common set of criteria and expectations.
- The department and the university must consider broadly the contributions the candidate has made and is likely to make to the department and to the university over a working career.
- The evaluation of the candidate's research accomplishments and potential must not be based entirely on a count of publications or pages. Depth, breadth, and impact of the candidate's research program must be taken into account. External evaluators should receive full information about the tenure clock of the candidate, including instructions about how to incorporate this into their discussion of pace.
- Those involved in decision making must be aware of ways in which the tenure process is at risk of being compromised by evaluation bias.
- The department and institution must recognize the importance of leadership in the department and the university for the outcome of a candidate's tenure case. Having women in positions of leadership within the department and the university often enhances the department's ability to mentor and counsel women tenure candidates.

§2. Environment and Climate

Departmental Culture. We begin this section by noting that there are departments in all three countries that are justly renowned for establishing an inclusive and friendly working environment.

We apply recent studies and analysis [2] to the working environment of mathematics departments. Departmental culture must be built on positive mentoring in a nurturing,

supportive community that encompasses undergraduates, graduate students, postdocs, junior and senior faculty. In this section, we begin by summarizing the apprenticeship framework [9] in which the development of mathematical careers can be studied, and indicate how traditional mathematics departments fall short. Then we identify three areas in which departments can monitor and improve their culture.

Mathematical Career Development as Apprenticeship. The professional development of students, postdoctoral fellows, and new faculty can be viewed through the lens of apprenticeship [9]. Social science research on the nature of apprenticeship reveals a number of common principles across a broad range of work and cultural settings. First, apprentices learn through their *interactions* with the masters. Second, while apprentices begin with tasks that are peripheral to the main work of the masters, the tasks in which they engage are *authentic* parts of the work of the craft. As they develop increased mastery, they are assigned more responsible and central tasks of the craft. Through this process, novices

- *learn the craft* (mathematical concepts and techniques).
- *learn to act as craftspeople* (participate in all practices of the mathematics profession: problem solving, writing proofs and papers, research, participating in conferences, teaching).
- *develop an identity as mathematicians or as mathematicians-in-training*.

Faculty should be encouraged to use this framework as a model for mentoring junior members of the mathematical community by engaging them in authentic mathematical tasks at increasing levels of responsibility, in ways that enhance their learning of mathematics and development of their mathematical identities. Graduate students in particular benefit from engagement in research, teaching and departmental outreach activities as soon as they arrive in the department, rather than only after they complete the required coursework.

Mentoring of postdocs and young faculty members is equally important. All too often it is assumed that a newly hired colleague possesses the requisite knowledge of the academic world, its rules and expectations. Lack of mentoring and guidance can harm or even cut short a promising academic career. It is worth noting that women hired through the Canadian University Faculty Award (UFA) and similar programs may be at special risk if they enter their positions with little or no postdoctoral experience. These awards are intended to accelerate women's careers by moving them more rapidly into the tenure stream. Care must be taken to ensure that being placed on the fast track does not result in being derailed. In this respect it is worth mentioning the anecdotal evidence that women apply for postdoctoral positions in lower proportion than their rate of attainment of Ph.D. degrees. While there are valid reasons for this – such as some women's desire to find permanent positions before starting their families, and the lower mobility of women with partners – there is also evidence that it results in part from many women's underestimation of their own potential as researchers.

Departments should develop models of mentoring which are appropriate for the needs of their junior faculty and which use available expertise to best advantage. For example, different faculty members can be mentors for different aspects of a career: research, teaching, manuscript and proposal writing, community involvement and so forth.

Guidelines for mentorship need to be developed, clarifying the responsibilities of a mentor and stating what mentoring is and is not. Many faculty members are reluctant to mentor their young colleagues because of misconceptions about what mentoring is, and how it differs from graduate supervision; for example, some believe that research mentoring would require co-authoring papers. An act of mentoring might be as small as an encouraging sentence recognizing the talent and promise of a junior colleague. Coming from an esteemed senior colleague, such a gesture can dramatically raise the professional sights of a novice.

Mathematical Identity and Sense of Community. Current mathematical training is focused mostly on mathematical content. While more recently some attention has been paid to issues of professional practices, the development of a mathematical identity has been largely overlooked. For someone who does not fit society's image of a mathematician, it is important to be secure in the knowledge that one's skills and interests do indeed match those needed for a successful and happy career.

People who have a strong mathematical identity are more likely to feel engaged in the scholarly community and to continue in the profession. While all individuals face some obstacles to a sense of belonging, women and people of colour often face additional obstacles, including absence of role models; difficulty in finding mentors; being marginalized or treated as "invisible"; being excluded from information and social networks; being socially ostracized (not "real" mathematicians, not "real" women); experiencing sexist or racist behavior; facing conflicting demands of family and career or community and career; shouldering the burden of having to prove their worth or represent their "kind," and, at times, overcoming the "impostor syndrome."

Three areas for action:

I. Expectations, Evaluation, and Feedback

Although it is clear that women and men should be subject to the same expectations, men are often better informed about expectations and evaluation methods, since men often have better access to informal social networks. To extend these advantages to all junior faculty, departments should

- Develop clear, transparent and detailed expectations, and criteria for satisfactory performance and career progress for faculty and for graduate students.
- Explain evaluation processes fully to new members of the community.

- Evaluate individuals regularly, in ways that correspond clearly to the stated expectations, and give them frequent and constructive feedback about their progress toward these expectations.
- Provide advice and guidance in a timely manner, to allow opportunity for correction and improvement.
- Make criteria and expectations flexible enough to allow for developing and displaying of individual strengths, and to account for special circumstances.

II. Fair and Equitable Allocation of Resources, Opportunities, and Responsibilities

The following are principal areas where departments need to monitor their allocation practices. Women and minority faculty members find themselves at a disadvantage both in knowing how much to demand or request, as well as facing the need to find the correct way to make requests, to avoid being perceived as inappropriately demanding or unreasonable.

Resources. Allocation of resources such as computers and offices may reflect seniority, but it is often the woman who struggles with old equipment and who is assigned the smallest and least comfortable office. The chair should explain how assignments are made, and endeavor to make a new colleague's working environment as supportive as possible.

Opportunities. *Travel.* The chair should explain what resources are available locally and how to obtain them, as well as point to external sources. Research travel can be crucial in the early stages of a career, and sometimes, owing to family constraints or safety concerns or lack of a colleague with whom to share a room, a woman mathematician's travel expenses are higher than the norm.

Staff support. The dynamic between a young faculty member, especially a woman, and the typically female support staff, can range from helpful to stressful. Part of the burden to make it helpful falls to the faculty member, but the chair's role is to make it clear both to faculty and support staff what kinds and level of support are to be made available.

Responsibilities. *Committee assignments.* These should be made to match the abilities of the faculty member with the task, and to develop each faculty member's understanding of the department and institution. A chair should resist asking too much of an eager and competent new colleague. All chairs should resist gender stereotypes in making assignments.

Course teaching assignments. These should also be designed to put the faculty member's best foot forward, as well as to provide an adequate range of different teaching experiences on which to base evaluation of teaching. The squeaky wheel sometimes gets the plum assignments, and women can be relegated to more onerous or less interesting

courses in which high interpersonal skills are needed. This may be practical but it is short-sighted on the part of both chair and faculty member.

Flexibility for Individual Circumstances. Personal situations of colleagues may require flexibility in course scheduling, committee assignments, and departmental meeting times. Faculty with young families may find it easier to attend departmental meetings and seminars at midday than in late afternoon. Hiring committee duties sometimes involve travel and meetings over dinner; junior faculty should not be required to be available after hours. Many academics are juggling two-body/two-city situations, and may need for a time to acquit their duties on campus in fewer than five days.

III. Bias and Other Climate Issues

Departments need to periodically examine whether their climate and level of collegiality foster growth and development of all their members. Climate issues in need of improvement need to be identified and dealt with quickly.

In most universities, institutional policies on harassment, discrimination and other human rights exist.

- Departments need to insure that all faculty members, students and staff are aware of and understand these policies, and that they feel secure enough to discuss any breaches of these policies.
- Issues of personal relationships and power need to be addressed in open discussion.
- A meeting at the beginning of each term, perhaps with a trained convenor, could serve to introduce people to each other and to discuss these policies and to consider sample instances where they might be breached.

§3. Family and Personal/Professional Life Balance

The mathematics community is comprised of people who have invested many years of education in their chosen careers, and in whom the community itself has invested training, time and money. The perpetuation of barriers which prevent a healthy balance between work and personal life, and the exclusion of those that choose to start a family or to care for an elderly parent, unnecessarily narrow our collective talent pool, and fail to maximize the potential of our community. Furthermore, all of society gains when individuals are able to be active members in their families and communities. Deep engagement in family life is not, nor has it ever been, antithetical to a successful, productive research career.

The basic principle is *flexibility*. Mathematics is particular among the sciences. We are fortunate in that we are well positioned to offer flexibility. We generally do not do field work or run large labs with intricate equipment; the material in most courses that we teach does not risk becoming obsolete, nor does it change in short time periods. There is

an acknowledged need to diversify our talent pool, and mechanisms which encourage personal/professional life balance are powerful recruitment and retention elements.

Institutes, professional societies, and department chairs can take an active leadership role and should experiment with policies and programs for researchers in transition.

Professional Associations and Societies. An important role for the mathematics professional associations and societies is to advocate on behalf of their membership. Societies can

- Publicize useful studies of good practices.
- Publish, propagate, and endorse specific recommendations.

Institutes and Funding Bodies. The following suggestions are appropriate for regional and national organizations dedicated to supporting research.

- The mathematics institutes and funding agencies can create opportunities for re-entry into research by offering targeted fellowships, particularly during thematic programs. This is a simple way to “recover” a research mathematician who has fallen out of the loop owing to a temporary break from research for family or personal reasons.
- Institutes are well-positioned to offer (multi-year) temporary solutions which may help offer a dual-career couple sufficient flexibility to find a permanent solution. For example, grants for part-time researchers are an excellent tool for accommodating a trailing spouse. These can also allow someone whose family obligations do not allow them to hold a full-time position to nevertheless continue a research career at an appropriate pace.
- Funding bodies can also help by making childcare allowances available as part of grants for conferences and other scientific activities. Grant applicants should be encouraged to request such support, so that the funding bodies must either reject such requests or modify their policies.
- Granting bodies should develop research-enabling grants for primary caregivers. This can be in the form of childcare support, or as part of a re-entry strategy.

Departments and Department Chairs. A sympathetic department chair can make an enormous difference in helping someone strike the correct balance, and in defining expectations and roles. This is good policy for the department as stable, content faculty members are ultimately more productive (and replacing faculty members who drop out requires time and energy from the department).

- Help your faculty members return to a productive research level by scheduling research semesters appropriately around a leave, and by reducing teaching loads directly after a leave.

- Consider altered evaluation criteria for just cause. For example, if a parent has limited travel opportunities because of family obligations, work with them to figure out other ways to maintain and measure their visibility. Expectations should be clear and explicit.

University Administrations. Many recommendations need to be implemented at the university-wide level.

- True academic age should not count leaves; it is this true academic age that should be considered for the tenure clock, as well as for hiring procedures and performance evaluations.
- There should be clear policies for parental leave and for special circumstance leave. Once more, flexibility is crucial; for some, the opportunity to spread a leave over a longer period is desirable, and can provide a useful transition.
- Make a part-time (half or three-quarters) option available, in a way that parents and caretakers can transition back into their full-time researcher role.
- On-site, well-funded high-quality childcare is essential.
- Develop campus-wide programs for spousal co-hiring. Offer small research grants for trailing spouses. Make options for multi-year temporary positions.
- Formalize, publish and advertise some of the practices that departments already employ.

§4. Professional Development and Leadership

Just as it is important to ensure that women entering the ranks of academia have a chance to establish their careers, it is also important that women enjoy the fruits of their success and find their way to visible positions of leadership in the profession. This is important for at least three reasons: visibility of women role models is an effective way to encourage junior women to enter the profession; leadership positions are rewarding and prestigious, and so fairness demands that women have a chance to participate; women may bring different perspectives, skills and sensitivities to these positions in ways that improve the profession for everyone. Here we list some of the areas in which the needs of women for professional advancement can be recognized and met. Some of these repeat ideas stated earlier in this document.

Professional and Discipline Skills

- Institutionalize transmission of professional skills, rather than leave such acquisition to informal networks. Professional development panels at workshops

for women can focus on skills needed for grants, talks, meetings, jobs, and administrative positions such as department chair or leadership in professional organizations.

- Develop and publicize opportunities for women to expand their disciplinary skills and research programs. These might include networking events at conferences, or special workshops at mathematics institutes or research centres.
- Make clearer to junior women (and their thesis advisors) the important role of the postdoctoral experience in establishing a research career. At the same time, institutions that offer postdoctoral fellowships need to advertise proactively to women, and to modify the positions if necessary to accommodate women's generally lesser mobility (for example, by allowing for a delay in assuming the position).
- Provide scientific opportunities for re-entry after a break in career through institutes or conference funding, or for advancing one's research program to a higher level. One innovative way to do this would be via the rich variety of thematic programs at mathematics research institutes. Women should be encouraged to become active in these programs, as organizers or participants.
- Establish a special fellowship category available to women (or men) re-entering intensive research careers in an area related to a thematic program after a break for family responsibilities, perhaps with dedicated grant or private funding.
- Create new opportunities for mid-career women such as have existed in the past. These have benefited many of today's senior women. The National Science Foundation's Visiting Professorships for Women and Professional Opportunities for Women in Research and Education awards are two examples, but neither program exists currently; the Association for Women in Mathematics's privately funded Michler Award fills a similar niche, but at the rate of one fellowship a year. None of these awards explicitly recognized the need for special support to enable women to resume their careers, however.

Visibility and Leadership

- Increase transparency of access to opportunities (editor, organizer, professional society committee and officer) by encouraging societies to provide programs and information in their publications about how one may participate.
- Mentor junior colleagues on how to participate in extra-institutional activities.
- Propose junior colleagues to selection committees for appropriate roles in refereeing, organizing meetings, committee service.

- Assign junior faculty to visible positions and committees (for example, colloquium chair).
- Create programs for graduate students and postdocs to learn about the variety of leadership activities available in the mathematical community, and about what skills one needs to develop leadership and visibility.

Mentoring and Support

- Provide training in mentoring skills for every faculty member.
- Develop guidelines for effective mentoring.
- Institute mentoring sessions for graduate students.

Conclusions

This report has attempted to be succinct rather than comprehensive. Important intervention strategies are described in summary form. Readers who wish to see more detail, including point-by-point rationales for the policies recommended here, are urged to consult the many studies listed in the footnotes. One size does not fit all, and not every institution or department will be able to implement all our suggestions immediately. But we have identified those areas which we are convinced have substantial impact on success, and we urge that all receive attention. Beyond individual departments and academic institutions, other organizations – professional societies, research institutes, advocacy groups (such as the Association for Women in Mathematics and committees on women within other societies), funding agencies and foundations are all charged with furthering these goals, in order to enhance the vitality of the mathematical sciences through their actions.

Detailing the impact that making these changes will have on the wider capacity increase mentioned in the introduction is not the business of this report. However, we wish to conclude by repeating the sentiment that motivated many of the participants in our workshop: the beneficiaries of the culture change that we recommend, that will allow women to reach their full potential as participants and leaders in academic mathematics departments, are not women only. The compelling reason for increasing the participation of women is the competitive imperative of our modern technological society – the need for an educated, scientifically literate workforce – and to ensure the continued vitality of mathematics. *Non nobis solum.*

Authorship

All the participants at the workshop have contributed to this report.

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